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Engineering News

Volume 76, No. 22
Issued Every Thursday
Hill Publishing Company

NEW YORK, NOVEMBER 30, 1916

Price, 15 Cents
Contents, First Page
Advertising Index, Last Page

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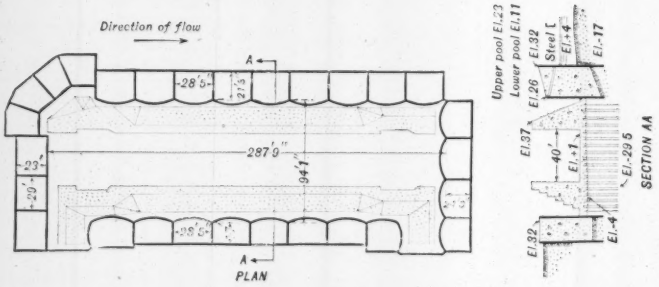
This order for 1,870 tons of Lackawanna Sheeting coming soon after the successful use of a similar quantity in a cofferdam to meet similar conditions in building Lock No. 1 at King's Bluff, 33 miles farther down the river, would seem to indicate the preference of Government Engineers for Steel Sheet Piling of the Lackawanna type.



The conditions at Brown's Landing are severe. The river is narrow, with low banks, highly water-bearing soil for sub-foundation, a water head of 31 feet, high floods to be expected at any time of the year, and only the least possible obstruction to the river is permissible.

It was figured that with a Lackawanna Steel Sheet Piling cofferdam as indicated by the sketch, the dredging could be completed, the bearing piles for the lock foundation driven under water with a floating pile driver, a bottom seal of concrete deposited within the cofferdam, and after unwatering, the lock walls could be built and the leakage kept out with a very small pumping plant. Once constructed and tested by a first pump out and first rise in the river, the cofferdam would need no further care. If the river did rise and overflow the unwatered structure, no harm would result as the water would fall upon a concrete floor.

This cofferdam is shown above at the time when the pockets had been filled and the concrete bottom seal was being deposited through a tremie. Further details will be shown and explained in subsequent advertisements.

Records of this and hundreds of other Lackawanna installations are in our files and subject to the use of prospective customers.

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Engineering News

VOLUME 76 NOVEMBER 30, 1916 NUMBER 22

Tunnel for Marseilles Canal Largest in World

In several recent issues of *Engineering News*, articles have appeared descriptive of the very large section tunnel now being driven just north of Marseilles, France, for the Marseilles-Rhône canal. Two of these articles (Aug. 26, 1915, p. 386, and Oct. 21, 1915, p. 803), gave the details of the section and the methods of driving the canal. At that time, however, photographs showing the work were not available. We have now, through the courtesy of the Department of Commerce, been able to obtain some views of the tunnel and its environs, which will be received with interest by American engineers.

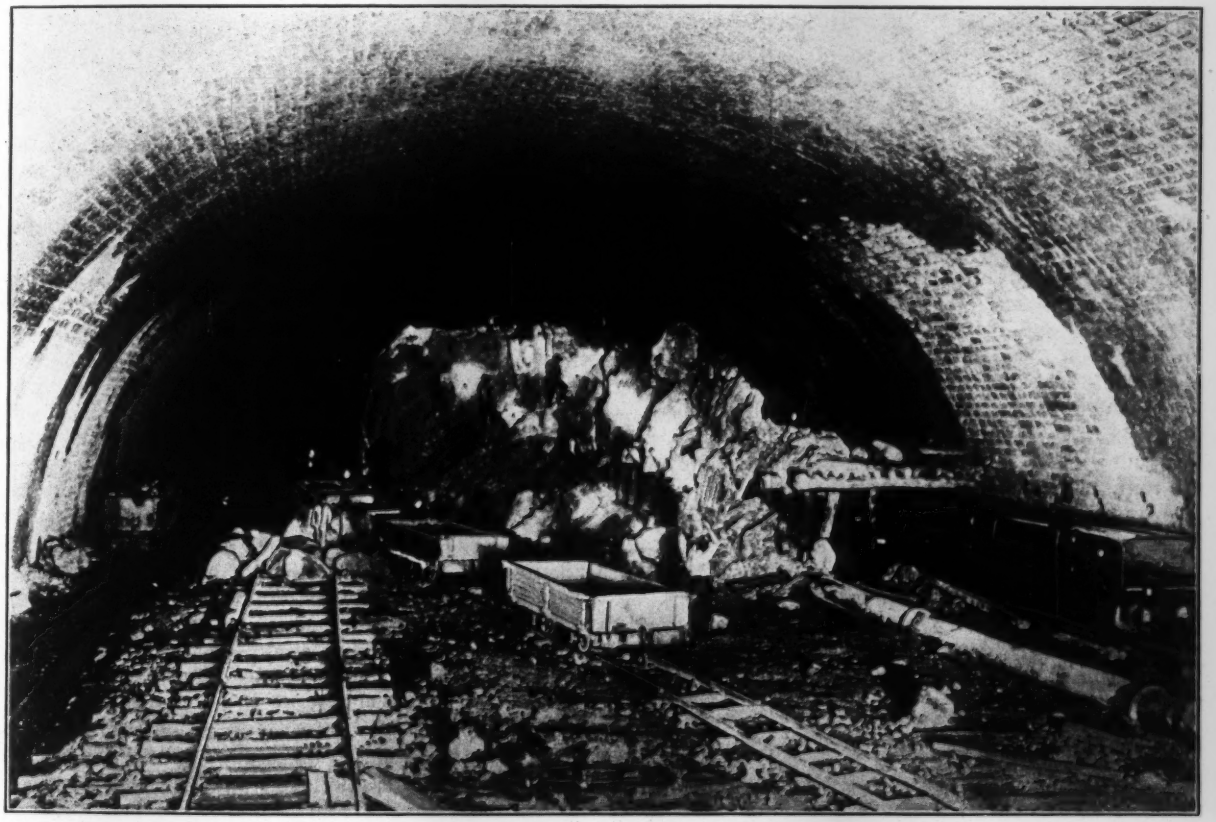


FIG. 1. REMOVING CORE OF LARGE TUNNEL SECTION, MARSEILLES-RHONE CANAL

The Marseilles-Rhône canal extends from the Rhône River at Arles to the Bay of Marseilles. For a distance of 20 mi. it practically parallels the river, but as the river approaches the Mediterranean the canal turns to the east and goes along the shores of a bay there and then cuts directly through the high ridge of mountains extending just back of the City of Marseilles. Emerging from this ridge, it passes around Marseilles Bay within a breakwater to the harbor of the city.

The total length of the canal is 51 mi. Its typical section is 82 ft. wide and 10 ft. deep. It is being built not only to take care of the traffic in the lower Rhône, which is somewhat difficult of navigation, but also to insure the passage of the Rhône barges directly into the harbor of Marseilles without having to pass around the turbulent waters of the cape just west of the city. For many years the project had been held up because of the difficulty of getting through the mountain ridge north of the city; but the present project, initiated in 1903, penetrated this ridge with the so-called Rove tunnel, which is now being constructed. The tunnel heading was carried through last winter, and it is understood that work on the construction is continuing in spite of war conditions.

The view on the next page is taken from one of the breakwaters in Marseilles harbor, looking toward the ridge

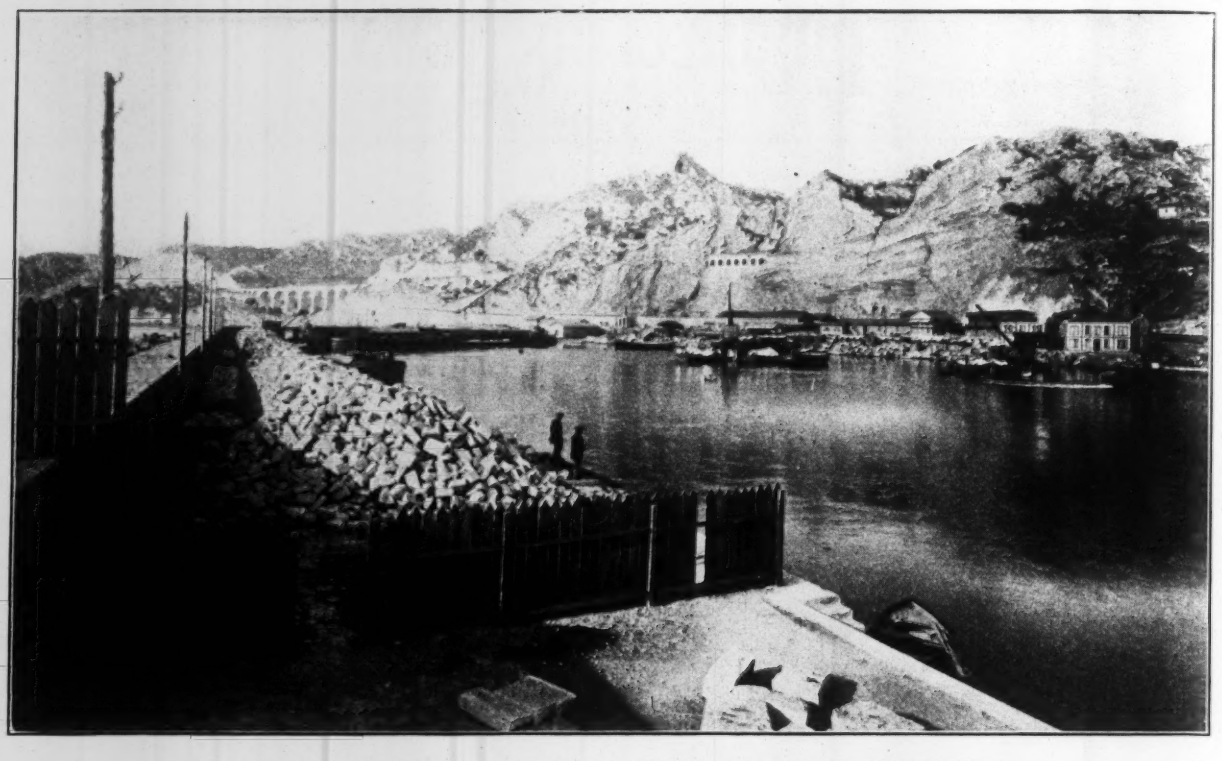


FIG. 2. MARSEILLES HARBOR, LOOKING TOWARD PORTAL OF ROVE TUNNEL

of hills that the tunnel penetrates. The tunnel portal may be made out just below the side-hill viaduct about halfway up the hill in the center of the picture.

The Rove tunnel is 4½ mi. long, and the typical section has a square invert 59 ft. wide and 15 ft. deep with approximately a semicircular arch of 41-ft. radius, giving an excavated section 79 ft. wide and 50 ft. high, with a clear area of 3,250 sq.ft. This section, it will be noticed, is about six times as great as an ordinary double-track railway tunnel. The comparison of the amount of yardage in the tunnel with the yardage of several other large European tunnels is given in the accompanying table. It will

RELATIVE LENGTH AND CUBAGE OF FOUR EUROPEAN TUNNELS

Name	Length in Mi.	Excavation in Cu.Yd.
Rove	4.5	2,800,000
Simplon	12.3	2,100,000
St. Gothard	9.3	1,300,000
Loetschberg	9.1	1,000,000

FIG. 3. MARSEILLES-RHONE CANAL IN DEEP CUT NORTH OF ROVE TUNNEL

not only have the greatest section, but will have the greatest length of any tunnel built completely in French territory.

As described in previous articles, tunnel construction is carried on from three arch headings, which are opened one into the other, leaving a central rock section to be removed. The view on the first page, taken inside the tunnel in the present year, shows work going on in the removal of this central section and illustrates very well the enormous size of the arch. As shown there, the lining is of masonry, which is backed on concrete made of a special lime and not of portland cement. The driving was started at both portals, and the work is being carried on from each end. It is being driven in rather hard rock that requires little timbering, with hand-handled air drills that work very well, an advance of 15 to 18 ft. a day being made in the headings, which are about 100 sq.ft. in section. The spoil is taken away on small trains running in the side heading and drawn by compressed-air locomotives in the headings and by steam locomotives in the main section. Little water has been met, and what has filtered into the tunnel is taken away by side drains. Artificial ventilation has been resorted to.

The south portal of the tunnel, shown in the view in Fig. 2, is in the face of the cliff. The north portal, however, emerges toward a bay in earth, so that the approach for a distance of a mile is in a deep cut that is being excavated with steam shovels. Fig. 3 shows the general type of section here and one of the handsome masonry bridges crossing the canal.

The construction of the tunnel is being done by Leon Chagnaud, a well-known French contractor who is noted in Europe for his work on the Paris subways and on the Loetschberg tunnel.

A very complete article describing the canal appears in *Le Génie Civil* for May 20, 1916.

Outlet Control of Elephant Butte Dam

By F. Teichman*

The Elephant Butte Dam, recently completed by the United States Reclamation Service, is located on the Rio Grande in New Mexico, about 120 mi. north of El Paso, Tex. It has a height of 200 ft. above the river bed and will store, for level of permanent spillway crest (7 ft. below the top of the dam), 2,638,000 acre-feet for the irrigation of about 180,000 acres in New Mexico, Texas and Mexico.

The different outlets of the dam are arranged near its east abutment. There is a total of twelve passages piercing the dam, all of the same area: Six passages 3 ft. 11 in. by 5 ft. for power purposes (penstocks), three of which have their center 20 ft. above the river bed, the other three being 30 ft. 8 in. vertically above the first; two sluice passages of the same dimensions and on the same level as the lower penstocks; four service passages 5 ft. in diameter controlled by balanced needle valves, two of these having the center of their seat at the level of the center of the sluice passages and the lower penstocks (20 ft. above the river bed) and the other two having their seat 56 ft. higher. Each of the twelve passages is a complete unit by itself except the service passages. One lower and one upper service passage take the water from the same well, entrance to which is had through two gates 3 ft. 11 in. by 7 ft. 6 in. There are then two service units each with two balanced valves and circular outlet passages of 5 ft. diameter.

Each of the several outlet units of the dam has a double means of closure. In the case of the two service units this has been indicated above; the outer slide gates, 3 ft. by 11 in. by 7 ft. 6 in., are always wide open or fully closed and are called the emergency gates; the inner balanced valves control by their degree of opening the amount of discharge of service water. The two sluice passages have each two slide gates 3 ft. 11 in. by 5 ft. placed in tandem, 25 ft. between the faces of the gates. The conduit is formed in cast iron to a point of 12 ft. 2 in. below the face of the downstream gate and then presents concrete surfaces. In the case of the sluice passage the downstream gates are the emergency gates (always wide open or fully closed), and control is had by means of the upstream gates. Thus the jet from under the controlling gate has to pass 37 ft. 2 in. of cast-iron lining before entering the concrete passage, and less harm is expected to the passage by having the upper gate control the jet. Each penstock has one slide gate 3 ft. 11 in. by 5 ft.; and at the downstream end of the cast-iron conduit, which here has assumed a circular section and is 24 ft. from the face of the gate, it is closed at present by a bumped head. When, in the future, these penstocks are connected with a power plant, this head will be replaced by a spigot end of 5-ft. pipe with lead joint designed for internal calking. The lead-jointed pipe will be continued to the power plant (inside calking inside the dam body), and the penstock will there receive its second gate.

Besides the two means of closing any of the twelve passages through the dam, there is a third means provided in the form of a steel shutter, built up of a 5/8-in. plate, I-beams, etc., which may be let down from the top of the dam over any one of the twelve entrance castings of the 3 ft. 11 in. by 5 ft. or 3 ft. 11 in. by 7 ft. 6 in. slide gates. The entrance opening of all these twelve castings is the same, 5 ft. 5 in. by 8 ft. 8 in., so that the same shutter of 6 ft. 5 in. by 10. ft. 6 in. can be used to cover any opening. There are seven shutter chutes provided, reaching from the top of the dam to the face of the entrance casting, one chute for each of the sluice passages and one chute for each pair of penstocks or service passages that lie in one vertical plane. The shutter is let down through these chutes by means of a shutter winch, motor-operated and on wheels, so as to be easily movable from one chute to another. The chutes are inclosed passages near the dam face and therefore cannot be obstructed by drift. Of course, the use of the shutter for the closure of a passage is possible only if one of the gates of such passage can be closed (likewise one gate of that passage over which the shutter may have to pass in order to reach a lower passage to be closed). The shutter is a means to make inspection and repair of any of the upstream gates possible at any time. The hydrographic conditions that control the operation of the reservoir are such that it cannot be expected that any of the upstream gates will be-

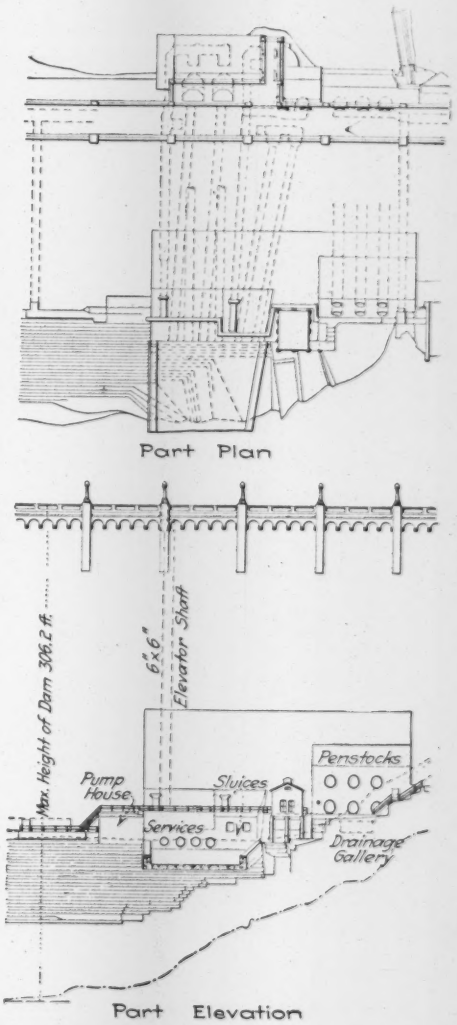


FIG. 1. PLAN AND ELEVATION OF PART OF ELEPHANT BUTTE DAM, SHOWING OUTLET CONDUITS

*Engineer, United States Reclamation Service, Washington, D. C.

come accessible by virtue of lower water level in the reservoir.

Besides the twelve passages through the dam above spoken of, there is a thirteenth, a 15-in. diameter penstock starting inside the entrance casting of penstock No. 6 and supplying the energy for a small power plant, placed on the toe of the dam, which plant serves the local requirements of the dam and of its attendants as to light and power.

The reservoir carries a considerable amount of drift that would be a menace in the penstocks and also in the balance valves. For this reason a straining structure of reinforced concrete is arranged, the lower part of which expands horizontally to cover all entrances and extends to 58 ft. above the river bed. It holds back the débris by permitting entrance to the tower only through a large number of slots of 3-in. width. Above this lower part the structure continues as a tower of 12 ft. 6 in. by 26 ft.

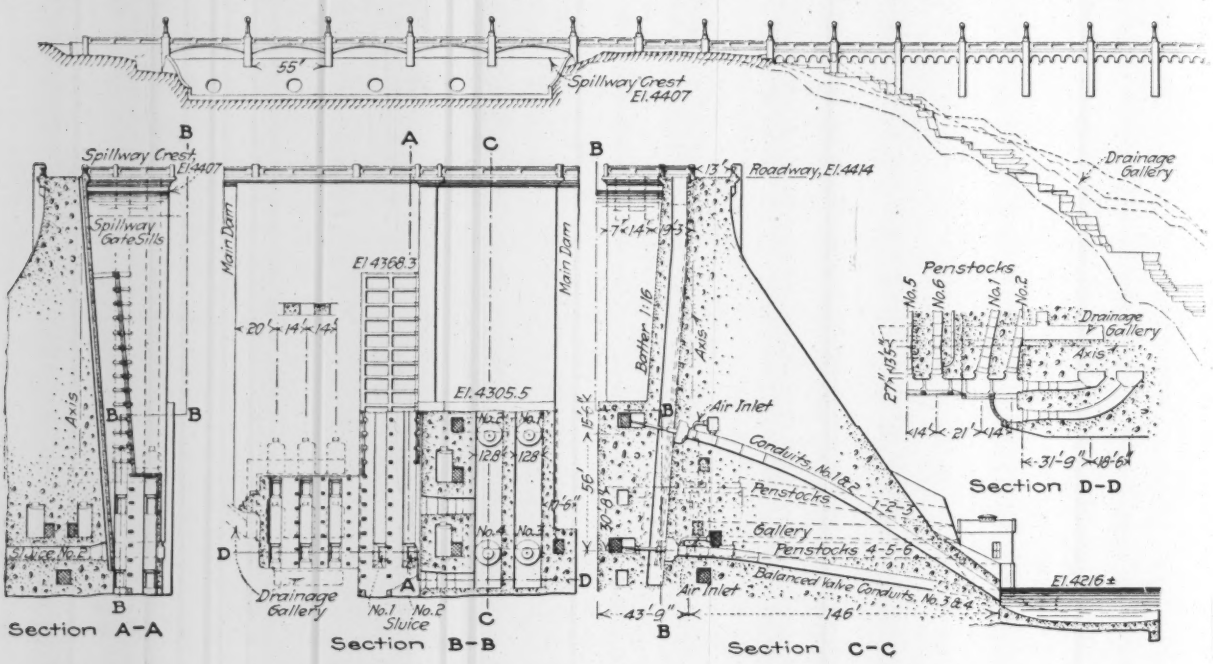


FIG. 2. DETAILS OF OUTLETS OF ELEPHANT BUTTE DAM

4 in. to a point 153 ft. above the river bed, being built parallel with and against the water face of the dam, which at this place has an incline of 1 to 12. The slots of this tower are 4½ in. wide. The great height of the straining tower was conditioned by the absence of any relation between the irrigation period and the location of water levels in the reservoir and the duration of such locations.

The service of irrigation water through the dam was assumed as 2,400 sec.-ft. to be furnished in part through the penstocks after the installation of the power plant. Until then the service and sluice gates must furnish this amount. The two levels of the four service gates are so arranged that the maximum functional head of the upper balanced valves (the static head of the spillway level plus the suction head at the point of issue of the jet) is about equal to the maximum functional head of the lower balanced valves obtaining when these latter must be put to use because the upper valves, wide open, cannot furnish the required 2,400 sec.-ft. on account of the lowering of the reservoir level (to about 45 ft. below the spillway). As a matter of fact, the maximum functional head of the upper valve is made somewhat smaller than that of the lower valves, because the upper gates will have to pass more water under their maximum head than the lower valves. After the reservoir level has dropped to about 100 ft. below the spillway, the two lower balanced valves, wide open, will not be able to discharge 2,400 sec.-ft., and then one sluice gate may be opened wide (72 ft. static head) and the deficiency supplied by control of the balanced valve. Finally, both sluice gates are opened wide, and a balanced valve controls the deficiency. Such disposition is of course much preferable to the one where the needle valve is wide open and the partial opening is made with the sluice gate, the advantage of the former being due to the solid jet from the needle valve for any opening and the absence of metallic vibrations such as may occur at the lower end of the partly open sluice-gate leaf.

A 5-in. diameter bypass connection is provided for the upstream and for the downstream sluice gates and a 6-in. bypass for the slide gates of the service wells. A bypass for the penstock gates will be arranged later, at the toe of the dam, making a connection from the 15-in. penstock to all of the 5-ft. diameter penstocks. Thus all the slide gates can be relieved from pressure, which is of importance when it comes to open a gate under a heavy head after it has been closed for a long time and become "frozen" to its seat. Of course, any of the slide gates may in an emergency have to be closed under full head, but to close a slide gate under high head requires less force than to open it under the same head, especially if it had been closed for a long period.

As stated above, the passages of the needle valves as well as the sluice passages will serve for irrigation water. These six passages converge toward a pool at the toe of the dam which is provided with heavy curved concrete floor and sides so as to prevent attack on the river bed on the part of the issuing jets. The convergence of these six

passages required curvatures of the passages in their vertical planes, and these curvatures were made so that the jet under maximum possible head will hug the bottom of the passage.

A generous supply of air under atmospheric pressure to the point of issue of the jet from a slide gate or needle valve under high head is of importance, especially for partial openings of these gates or valves. Such air supply will reduce or destroy the partial vacuum created by the jet and thereby will reduce vibrations, will make the jet more steady and prevent the detonations that may be occasioned by the entrapping of air by the jet and its subsequent release from under pressure into a partial vacuum. For this purpose the gates that will work with partial opening—the upstream sluice gates and the needle valves—were provided with air inlets just below the seat of these gates or valves. Each upstream sluice gate has four 3½-in. diameter pipes terminating in the roof of the passage just beyond the face of the gate, and these pipes run into a manifold with 7-in. diameter pipe connection. The needle valves have each a 12-in. diameter air connection.

The air is brought to annular conduit surrounding the liner of the 5-ft. diameter passage near the plane of maximum contraction of the jet, and from this annular conduit the air runs to the jet through a large number of holes in the liner. A larger air inlet, serving likewise as a manhole, is provided on top of the 5-ft. diameter passage about 16 ft. downstream from the seat of the needle valve.

All gates and valves are operated from chambers inside the dam body. The chambers of the same battery of gates are interconnected, but the chambers of different batteries, as a rule, are not. This is done to prevent flooding of the chambers of one gate system by a possible accident in a chamber of another gate system. Thus the chambers of the penstocks are interconnected, and they have their individual gallery of access (*A*), shown in Fig. 2.

The chambers of the two upstream sluice gates are interconnected (also shown in Fig. 2), as are those of the downstream sluice gates, but each system has its own gallery—gallery *B* for the former, the drainage gallery of the dam for the latter—and one gallery cannot be flooded from the other. The lower needle-valve chambers are nearly on a level with the floor of gallery *C*. This gallery has a riser to the chambers of the upper needle valves. The four chambers of the needle valves—being the valves that need most frequent attention—and gallery *C* can also be reached from the top of the dam through a vertical elevator shaft. This elevator will be used by the attendants of the power house on their way to and from their dwellings on the hill above the dam. The slide gates of the service well are accessible from the same gallery *B* that connects with the chambers of the upstream sluice gates.

The numerous passages, chambers and galleries in the body of the dam required an addition to the upstream and downstream faces of the dam throughout the block in which they occur. These additions are made large enough so that the critical stresses in the dam body are not larger here than elsewhere.

The Elephant Butte Dam has been referred to in several articles in *Engineering News* as the storage dam of the Rio Grande Project, United States Reclamation Service, A. P. Davis, Chief Engineer, L. C. Hill was supervising engineer and later consulting engineer, E. H. Baldwin, succeeded by L. J. Charles, was the construction engineer. The writer designed the outlet control system and gates.

Booster Pumping Station for Water-Supply to a Suburb

The municipal water-works system at Sioux City, Iowa, includes a booster pumping plant for serving the suburban district of Morningside, and this plant is to be enlarged after five years' successful operation. The district has a 10-in. main with 6-in. branches. The elevation of the district is 164 to 170 ft. above datum, while that of the city reservoirs is 264 ft., and recording gages on the hydrants showed pressures of only 22 to 31 lb. To give an adequate fire pressure it was proposed to build a pumping station between the city proper and the suburb, delivering water to a standpipe 120 ft. above the highest point of the latter, or about 270 ft. above datum. However, the cost of this was prohibitive.

The plan adopted was to build a substation at a point 115 ft. above datum, where the static pressure is 50 lb., and to install three two-stage centrifugal pumps. Each of these has a capacity of 370 gal. per min. when pumping against a head of 215 ft., and when they are drawing at the rate of 1,000,000 gal. per day the pressure in the suction main will not fall below 15 lb. Each is driven by a 40-hp. 500-volt electric motor, running at 1,200 r.p.m. One pump is used as a relay and is operated only in case of a large fire.

The pumps deliver the water into a header connected to a steel compression tank 6x23 ft. This is provided with a small motor-driven air compressor, which keeps the tank more than half full of compressed air, forming an expansive cushion which maintains the water pressure between the time of stopping and starting the pumps. An electric regulator starts them automatically when the pressure falls below 50 lb., and stops them when the pressure reaches 100 lb. A new 12-in. supply main has been laid recently to this booster station.

Water is pumped through the 10-in. discharge main for a distance of 3½ mi. Pressure tests at hydrants about 1 mi. distant (using four streams from 2½-in. hydrant connection and 1-in. nozzles) showed 65 to 75 lb. pressure at the nozzle, with vertical streams thrown to a height of 84 to 90 ft.

The mechanical efficiency of the pumps was 75% at the time of installation. Current is taken from the lines of the Sioux City Gas and Electric Co. and the Sioux City Service Co., connections being so arranged as to prevent loss of power in case of accident to either line. It is furnished at the flat rate of 2c. per kw.-hr. The average monthly consumption is 3,000 to 3,150 kw.-hr., with bills ranging from $42 to $64 per month. The booster station now furnishes water to 1,980 service taps in the suburban district.

This plant was designed by F. W. Cappelen, consulting engineer, of Minneapolis, Minn. Plans for its enlargement, along the lines of the original installation, have been ordered by J. M. Lewis, Commissioner of Parks and Public Property, who described the system in a paper presented at the recent meeting of the Iowa and Illinois Sections of the American Water-Works Association, at Davenport, Iowa.

Maintenance of Macadam Roads with Bituminous Binders

By Theron M. Ripley*

SYNOPSIS—A summary of experience on Division No. 3, New York State highways, with recommendations for practice based on this experience; a detailed description of procedure.

Aside from the interest that highway engineers have in the use of bituminous oils[1] on roads, every automobilist has a more or less personal interest too. Probably no other portion of highway construction or maintenance has so many disrespectful things said about it. It dirties the car, and father and son lose their temper. It spots mother's new veil and sister's white hat, and they, also, become peevish.

Cold oiling to a macadam road is what the bath is to the small boy. He may not like it, but it is good for him; and no substitute has been found. The period of bad traveling, over any particular piece of oiled road, should not exceed one week during the months of July and August, and frequently it is less.

Two General Classes of Macadam To Be Maintained

The macadam roads of New York State are of two general classes—waterbound and bituminous-bound (penetration method). Both need constant maintenance, and a light application of bituminous oil, so far as shown, is the best "life-saver."

Waterbound roads, subject to horse-drawn traffic of medium weight, have remained in fair condition for a number of years with little or no maintenance—so it is said. Under a traffic consisting of horse-drawn and motor-driven vehicles it is known that many waterbound roads rapidly go to pieces.

This can be readily accounted for as the horse-drawn traffic loosens the top stone, the motor traffic raises the loosened binder, and the wind floats it into the adjacent fields. Further, a heavy, fast-moving motor vehicle not only displaces the loosened stones, but frequently throws them from the roadway.

Dust spells deterioration. The principal function of the first application of cold tar to a waterbound road is as a dust layer. The dust or binder remaining in place

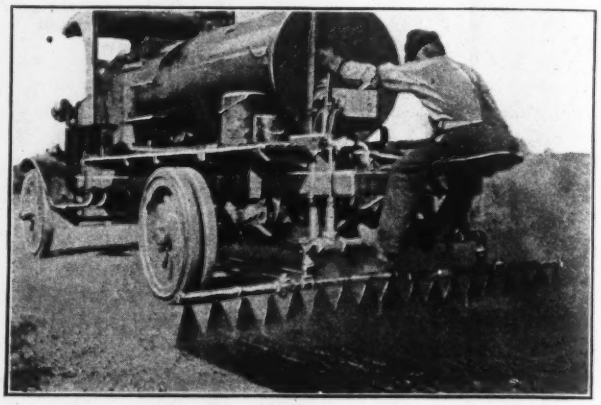


FIG. 1. MOTOR TRUCK DISTRIBUTOR FOR COLD OIL USED BY JEFFERSON COUNTY

assures the stability of the top stone, and the road then wears out only by the actual grinding away of the road metal.

Some Specific Examples

For example, take three roads, one built in 1914, two in 1914-15—call them roads Nos. 1, 2 and 3. No. 1 was built by a firm from eastern New York; No. 2 was built by a firm from New England; No. 3 was built by

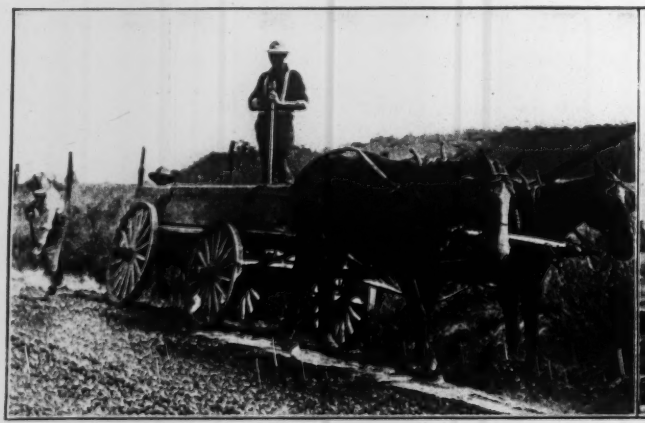


FIG. 2. SPREADING 1-IN. STONE AFTER THE FIRST POUR

Note the rut made by the wheels of the distributor in the center of the road. This rut requires careful manipulation of the roller to obtain a smooth road. Owing to this condition, contractors are advised against using this type of distributor for the application of binder for penetration

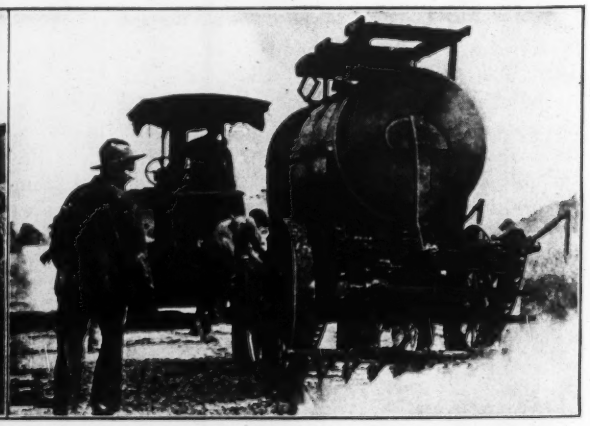


FIG. 3. "MONARCH" DISTRIBUTOR HAULED BY ROLLER, MAKING FIRST POUR

It is necessary to go over the road twice in order to secure the necessary amount of material for the first application. The machine is delivering about 0.4 gal. per sq.yd. per pour. After the first pour just enough 1-in. stone are spread to prevent the wheels sticking during the next pour

*Division Engineer, New York State Highway Department, Watertown, N. Y.

[1]The word oil is used throughout the text to denote bituminous materials in liquid form, although they are not oils in any true sense.

FIG. 4. BATTERY OF 100-GAL. HEATING TANKS

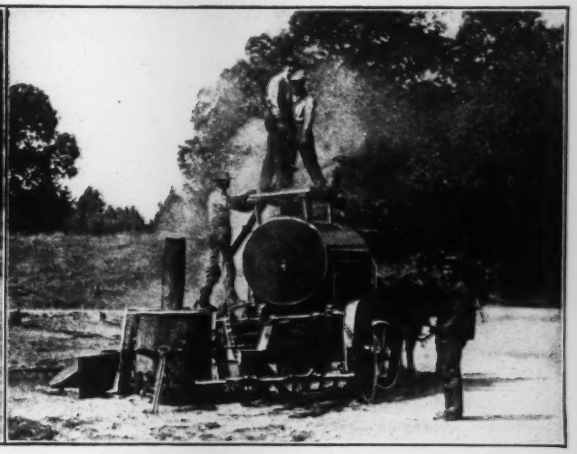


FIG. 5. TRANSFERRING HEATED ASPHALT FROM THE HEATER TO DISTRIBUTOR

In these pictures of heater and distributor it must be borne in mind that we have used the equipment at hand and not that it is necessarily the most economical. An economical equipment for this class of work would be larger heating tanks and a different type of distributor which would require but one pouring for an application of any amount required

a firm from the western part of New York. All were firms that had built earlier roads.

The results were: Road No. 1 was in fine condition in the fall of 1914 and early spring of 1915; it began to ravel in May, 1915. Of road No. 2, the part built in 1914 was in fine shape until early June, 1915, when it began to ravel in small spots. Of road No. 3, the part built in 1914 was in fine shape until the early summer of 1915, when it began to ravel.

Road No. 1 was granite with limestone screenings for binder. Roads Nos. 2 and 3 were all limestone. From the foregoing it will be recognized that the roads all began to ravel about as soon as they dried out after the spring rains. They all became dusty, particularly Nos. 2 and 3.

The traveling public did not hesitate to write the state highway commissioner or personally tell the division engineer how miserable these roads were, how incompetent the State Highway Department employees were, or what a crime it was to waste the state's money in building such roads. So discriminating has become the road user that dusty roads, however smooth, are no longer fit to ride over (provided they have been built by the state).

Since the first application of cold tar to these roads—and Nos. 2 and 3 received an oiling as soon as they were turned over to the maintenance department—no word of complaint has been registered. What is now being offered is advice as how best to apply the oil and cover.

How, When and Why To Apply Oil

A cold-tar application on waterbound roads should be made annually until a thin bituminous mat has been formed upon that portion of the road taking the most of the wheel impact. Upon roads having an exceptionally dense and large proportion of pneumatic-tired traffic this mat may extend over practically the entire width of the road after the first or second application, but on the large majority of roads it will be impossible to obtain this mat over the crown and along the edges until after at least two and probably three applications. This usual condition is due to the cutting of the mat by horseshoes and the lack of sufficient "ironing" by the softer tires to keep it bound together.

The bituminous roads do not, usually, need a cold-oil treatment until after at least one year's use. But the mistake, frequently made in the past, was to wait too long before making the first application. This application should be made as soon as the stones are so much exposed that the road can be called toothy or chattery; and it must not be too chattery, for you will either wonder later where your cold-oil application went to, or be forced into using a heavier asphalt or tar binder with correspondingly heavier cover, the limit of which is hot oiling.

Some years ago it was a statement of derision and contumely to say, "You are building these roads for the automobile owner," and arguments were strenuously advanced to combat that statement. Today it is admitted that the roads *are* being built for the motor-car owner; for the automobile, truck and motor cycle.

During the period of time when the road is undesirable because of the cold-oil application, the interests of the Highway Department, as the road maintenance force, and the interests of the automobilist clash. This clash is unavoidable unless more money is spent to achieve the same results; namely, more cover must be used in order to practically smother or entirely blot the bituminous application and thus prevent it from sticking to the car or being spattered on the occupants.

The Process of Oiling Described in Detail

The process of cold oiling is very simple and consists of four main operations: (1) The patching of the road; (2) the sweeping of the road; (3) the furnishing and applying of the oil; (4) the furnishing and applying of the cover.

Patching should always be done by the departmental forces unless some unusual conditions permit a cost-plus-percentage contract. No lump-sum or unit-price bid can be intelligently made or will be faithfully executed on this class of work.

The last three operations can be done under contract, although departmental forces, with the necessary equipment and one season's practice, can save the bulk of the contract profit, cover only what is needed and so conduct the work as best to fit the road and traffic conditions.

Sweeping bituminous roads is frequently a joke and sometimes a calamity. This type of road is often as clean as wind and rain can make it, with the exception of a few inches on the edges. When sweeping is necessary, it is done usually with a horse-drawn machine, and it never should delay the work; moreover, the road must not be swept too far ahead of the oiling, as dirt from connecting roads, fields, etc., is constantly being brought upon the macadam. A few hand brooms should always be kept with the oiling gang in order that horse droppings, material missed by the sweeper, etc., can be removed.

The cold oil is usually shipped to the nearest railroad siding in tank-cars, thence pumped into the oiler or supply tanks and hauled to the site of the work. In some cases of long haul, small amount of oil and inadequate equipment, it is cheaper to purchase and deliver the material at the work, in barrels.

The value of the use of supply tanks for transporting the oil from the railroad to the work can only be determined for each individual case, as it depends upon the haul and the class of equipment. The use of supply tanks adds the cost of another pumping and the tying-up of more equipment, if anything goes wrong with the organization; nevertheless, with horse-drawn oilers or distributors the supply tanks are necessary for economy on hauls of more than 3 mi.

With this class of equipment the pumping of the oil is done by hand, using a heavy barreled boat pump and trough. With motor-distributor equipment upon which is mounted a power pump for transferring the material, much longer hauls can be made, and in the majority of cases the supply-tank equipment can be dispensed with.

Practically all the applications made on this division are within the range of ⅙ to ⅓ gal. per sq.yd. of macadam; and the majority are between the limits of 0.2 and 0.25 gal. per sq.yd. The oil is delivered from the distributor to the road under pressure through nozzles set into a horizontal pipe at the rear of the distributor. The pressure is provided by a pump built into or set upon the frame of the distributor for that purpose. The amount of material spread is varied by regulating the pump, changing the nozzles, changing the speed of the machine (horses or motor) or by any combination of the three.

The lighter applications are used upon bituminous roads in good condition and the heavier applications upon new waterbound macadam or macadam in poor condition—poor condition comparatively.

Covering a Cold-Oil Application

Immediately after the application of the bituminous material it should have a covering, as thin as it is possible to spread and cover the oil. Depending upon the weather, the character of the road, the oil and the length of the work, one or more men must be continually "touching up" with more cover the places that "bleed through." Each new application of covering material should be made as thin as possible in order that the amount used be a minimum, and that the road proper may absorb a maximum amount of the oil.

If clean, small stone are used for the first cover, sand, iron-ore tailings or even sandy loam in small quantities should be used as a second light-cover material. Small stone used without finer material is a perfect nuisance to automobile travel, being readily picked up by the tires, particularly if they are of the non-skid type. To bury the oil with clean stone so deep that traffic will not be unduly inconvenienced requires an excess of cover, and a large amount is eventually of no account as a wearing coat. The binder is too light (thin) to hold it in place.

The instructions should be: Put the cover on uniformly, as thin as possible, and often enough so that the road does not look greasy. Because an automobile traveling 25 or more miles per hour picks up some of the mat is no reason why more cover should be used, but it is a reason why the motor speeds should be reduced.

How and When To Do Hot Oiling

As carried on in this division, hot oiling is a process between cold oiling and resurfacing. The surfacing materials are greater in volume or size, or both, and the labor and machinery equipment more extensive than for cold oiling. Hot oiling is resorted to when the top course of the road is pitted or rutted, beyond repair by cold oiling, but when it is of sufficient thickness so that resurfacing is not required.

In general, the sequence of operations is as follows: Patching and shaping; cleaning (sweeping?); furnishing and making the first application of oil; furnishing, applying and rolling the No. 2 stone (1-in. stone); furnishing, heating and applying the second application of oil; furnishing, applying and rolling the No. 1 stone (½-in. stone).

After the material is delivered along the road the equipment ordinarily required is: One horse-drawn sweeper; one-half dozen rattan or wire push brooms; two or more heating kettles (250-gal.); one distributor with pump (same machine as used for cold oiling); one roller (8- to 10-ton); two or three hand pouring pots; shovels, picks and other small tools.

From 0.4 to 0.6 gal. per sq.yd. is applied at a temperature of about 250° F. to the old road, after it has been cleaned and patched. Patching also must include any small amount of reshaping necessary, for it is a doubtful proceeding to attempt to shape the road or remove any irregularities, except of minor degree, with the hot oil and its cover. The more regular or better shaped the road surface prior to the application, the better the finished job.

Immediately after the first application of oil the 1-in. stone is spread so as to have, as nearly as possible, but one thickness of stone on the oil. The oil should be covered, but the stone should not be piled upon each other. The roller is passed over the newly spread stone until the latter is crowded together, pushed down into the oil and the surface has a generally smooth appearance. If the stone is brittle, or softer than desirable, care must be taken not to over-roll and thus preclude the penetration of the second pour.

The second, or squeegee, pour is then made (0.3 to 0.4 gal. per sq.yd.) and the ½-in. stone spread upon it. The spreading of this cover or wearing course should be made as was the former—namely, thoroughly to cover the oil, but not pile up the material.

The rolling of the wearing course can proceed immediately if the weather is cool. On exceedingly warm summer days it may be necessary to keep the rollor off this course for several hours. After the oil has hardened sufficiently, and the rolling can be done, it should be

ontinued as long as other demands upon the roller will permit.

Hot Oiling vs. Cold Oiling

The value of hot oiling and the advisability of doing it are debatable questions on this division. Some roads treated in this manner two and three years ago are in fine shape; some are in miserable condition and the despair of the man in charge.

The kind and condition of the original surface, the amount of oil per application, the character of the stone used and the ability of the men on the job all are factors of what may be called the first term. The factors of the second term are the kind of oil, the kind and amount of traffic, and the air temperature. Asphalts are more susceptible to temperature changes than tars and have been practically abandoned for this class of work in this division.

If the application forms merely a blanket upon the old road with practically no bond, it will move under the traffic when such traffic is heavy enough or when the temperature is sufficient to soften the oil, or both.

In considering the two types of maintenance work as outlined in the foregoing it must be borne in mind that in general they are distinctive not only as to method of application, but also as to function. In considering the costs of this work it must be further realized that one method can and is frequently shaded into the other. Such shading can be intelligently done only on a basis of experience.

In the costs, following, only the types as distinctive will be considered—namely, cold oiling with light cover and hot oiling with heavier cover. The shadings or gradations will be neglected.

Cost Data on Hot- and Cold-Oil Applications

Labor is in general the same over the entire State of New York. The prices of asphalts and tars vary only as to freight rate; the price of stone and fine cover as to availability of supply—namely, from digging it out of a bank along the road to purchasing from commercial organizations and payment of freight and haulage.

Light covering material can be obtained upon only about 5% of the total mileage. Therefore, local material can be disregarded in a general cost statement. There are two commercial stone quarries in the divisional area of 7,700 sq.mi. Only one of these furnishes material that can be used by this department, and that one is on a branch railroad.

During the season of 1915, in Division 3 there was cold oiled, 240.45 mi. of macadam road, equal to 1,961,102 sq.yd. of metaled surface. This amount was divided as follows:

TREATED WITH TAR

Type	By Contract — Miles	Amount — Sq.Yd.	Cost per Sq.Yd.	By Departmental Forces — Miles	Amount — Sq.Yd.	Cost per Sq.Yd.
Waterbound	29.75	258,498	$0.04907	68.57	528,510	$0.04268
Bituminous.	18.18	157,643	.04824	32.16	270,995	.03754
TREATED WITH ASPHALT						
Waterbound	8.62	60,660	.03756	5.82	29,936	.03716
Bituminous.	75.55	647,390	.03857	0.80	7,470	.05055

The cost of tar (cold application) f.o.b. destination was 7c. per gal. in tank-cars. The cost of asphalt f.o.b. destination was 3.8c. per gal. in tank-cars. No local material was used for cover. The costs for contract work are the actual final estimates and do not include the departmental inspection. The costs for work by departmental forces are the actual payroll vouchers (including inspection) and do not include machinery depreciation.

The following costs by departmental forces are taken from Jefferson County work under Arthur G. Bruce, county assistant, for the reason that 85.53 mi., equal to 704,504 sq.yd., was done in that county. The remaining work was in widely scattered parts of the division, where most of the work was done under contract and where the equipment was more nearly incomplete. In Jefferson County two Packard motor trucks, one three- and one five-ton, were used for hauling materials and transporting men and equipment, thereby facilitating the work. The lighter truck was the more efficient. Neither cost, as shown, includes the division-engineer or Albany office charges.

A typical cost analysis of a contract job (cold application of high-carbon tar) is as follows:

Length of road—miles treated	14.77
Width of road—feet treated	16.0
Area of surface—sq.yd. treated	136,360.0
Average haul of material—miles	6.0
Bituminous material—gal. per sq.yd.	0.25
Cover—lb. per sq.yd.	14.0
Cost of sweeping and furnishing and applying oil and cover per sq.yd.	$0.04816

A typical cost analysis of a departmental-labor job (cold application of high-carbon tar) is as follows:

Length of road—miles treated	3.5
Width of road—feet treated	14.0
Area of surface—sq.yd. treated	26,940.0
Average haul of material—miles	6.0
Bituminous material—gal. per sq.yd.	0.25
Cover—lb. per sq.yd.	14.0
Cost of sweeping and furnishing and applying oil and cover per sq.yd.	$0.04005

The cost of hot oiling in 1915, based on the only job done (by departmental forces), was as follows:

Type	Miles	Sq.Yd.	Cost per Sq.Yd.
Bituminous macadam	1.6	11,260	$0.2387

In 1914, 14.57 mi. was hot oiled by two different gangs (departmental labor) as follows:

Type	Miles	Sq.Yd.	Cost per Sq.Yd.
Waterbound	14.57	102,572.8	$0.2002

A detailed statement of the 1915 hot-oil job is:

Cost of 1-in. stone delivered on shoulders of road @ $2.50 per cu.yd.	$863.00
Cost of ½-in. stone delivered on shoulders of road @ $2.50 per cu.yd.	
Cost of high-carbon tar binder f.o.b. destination @ $0.1075 per gal.	971.88
Cost of unloading and hauling high-carbon tar binder—4½ mi.—@$0.0087 per gal.	78.50
Cost of patching road, heating and applying tar and applying cover @ $355.89 per mi.	569.56
Cost of rolling (rollerman and fuel)	112.00
Depreciation on machinery (20% of purchase price)	93.00
Total cost	$2,687.94
Number of sq.yd. covered	11,260
Cost per sq.yd.	$0.2387

Highway Engineers Unpopular in Missouri—Apropos of Missouri methods of handling roadwork, commented on in "Engineering News," Oct. 19, one finds the following in the "Ewing (Mo.) News" of Nov. 2; it is a letter to the editor from one of his interested readers: "I notice in the last issue of your valuable paper, 'To abolish the office of Highway Engineer means poor roads.' Now, kind friend, a great many people think the salary of Highway Engineer taken from the road funds materially diminishes the progress of the roadwork. The salary alone would work many miles of road Just think! Four big special road districts in the county and they do their own work, and fully half of the remainder are worked by donation. Nearly all the neighborhood roads are worked by donation, and lots of the county-seat roads get large donations by the farmers and also by the townspeople. Now why pay a big salary to anyone to ride over the roads in automobiles and dictate to people how to do this and that, when the average road overseer knows as much or more than the highway man? The taxpaying people are beginning to realize that officers' salaries are the burden of taxation. We think it is time to cut some of them out."

New Type of Mattress Used for River-Bank Protection

By A. C. Everham*

SYNOPSIS—In this brush and stone mattress construction the stone is held in place between two layers of wire mesh connected by tie wires. It has been used successfully in emergency work.

To protect its right-of-way against erosion by the Missouri River, the Wabash R.R. during the past year has developed a type of mattress and bank paving that is slightly more expensive than methods formerly used, but is expected to be permanent and positive in preventing bank erosion. This method can be and has been used in extreme emergency.

The bank protection used successfully on the Missouri River by the United States Government engineers consists of a willow mat sunk in the river with riprap, and a bank paving of riprap or one-man stone above the water level. The bank is first graded to a slope of 1 on 3 by a floating hydraulic grader. The mat is 86 ft. wide and about 12 in. thick; it is woven on a barge and then floated and sunk by throwing the stone upon it. It is anchored to deadmen 16 ft. 8 in. apart (placed 8 ft. from the top of the graded bank) by pairs of ¾-in. cables extending (one under and one over the mat) to the outer edge. The bank paving is from 12 in. thick at the water's edge to 8 in. at the top of the slope and is covered with 2 in. of quarry spalls.

This type of construction is employed only during low-water periods, when the mat can be got well out into the river and the bank paved to the low-water line. The railways, however, have to work under very different conditions and often have no sufficient warning of trouble to enable them to take advantage of the most favorable and economical conditions. The river may begin to cut the bank 100 ft. from the tracks, and in a few weeks the railway is forced to move its tracks and perhaps move them several times before material and equipment can be assembled to fight the river.

These attacks come generally during periods of high water, when the velocity of the river is very hard to combat. The railway companies therefore are forced to spend large sums of money for work that is of no value after the river falls. It is almost impossible to use the methods of the Government engineers under these conditions, it being impracticable to hold the outer edge of the mat.

The new method of protection that has been developed consists in the construction of a special type of mattress designed and patented by A. O. Cunningham, Chief Engineer of the Wabash R.R. This mattress has been used successfully on the left bank of the Missouri River near

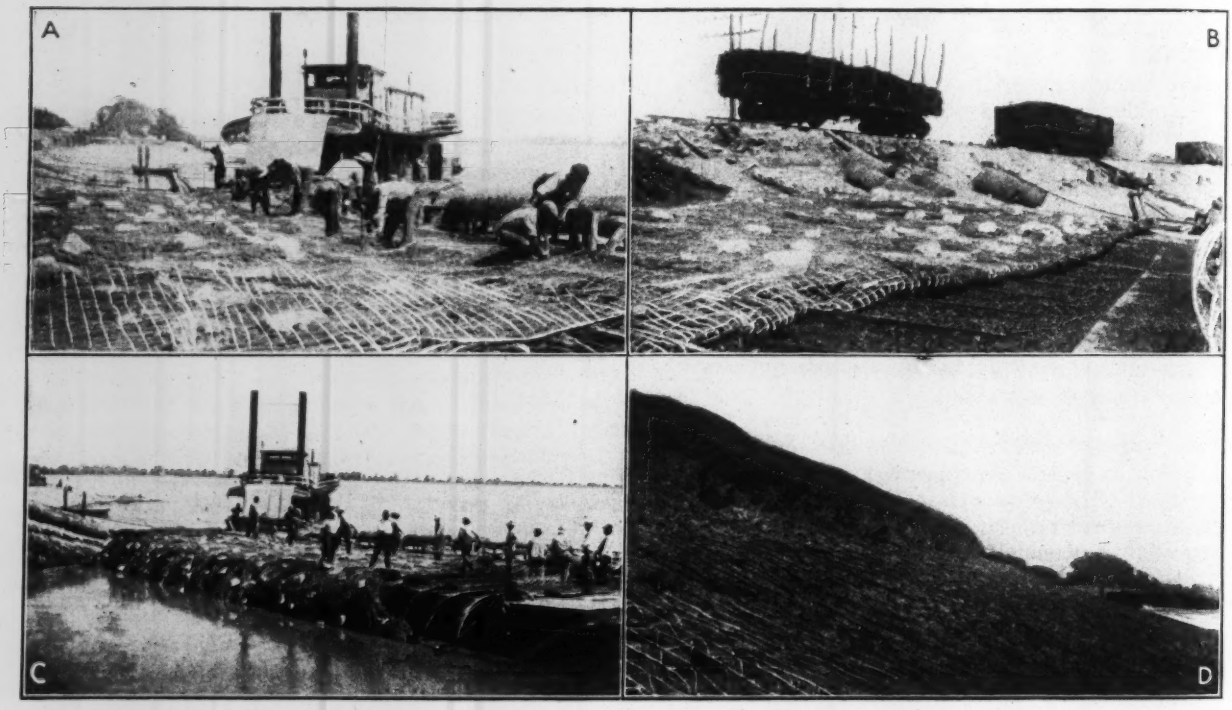


FIG. 1. MAKING THE CUNNINGHAM MATTRESS FOR BANK PROTECTION ON THE WABASH R.R. ALONG THE MISSOURI RIVER

A—Sewing the wire fabric. B—Mattress ready for launching. C—Launching the mattress from barge. D—Shore end of mattress in place

*Terminal Engineer, Union Pacific System, Kansas City, Mo. Mr. Everham was Engineer of Construction for the Kansas City Bridge Co., which had the contract for the work described.

Orrick, Missouri City and White Rock, all of which are between Kansas City and Booneville, Mo. The Cunningham mat, as constructed, consists of two layers of galzanized-wire fabric filled with brush and rock and tied through at 2-ft. intervals with galvanized wire. That part of the mat placed below the water level is filled with brush and riprap, while that part above the water's edge is filled with riprap only. Fig. 1 shows the work in progress, and Fig. 2 shows the details of construction.

To build the mat in the river, a barge was necessary, upon which a sufficient number of reel stands were provided to hold the galvanized fabric, which came in rolls 58 in. wide and 300 ft. long. As the fabric was unwound, the different widths were wired or sewed together with No. 12 galvanized wire, so that it made a continuous web the full width of the mat. At the beginning of the operation the wire was unwound so that the entire width of the mat (72 ft.) was laid on the deck of the barge. The edges were then sewed together. Willow brush was laid on the wire in two layers, the first one parallel to the flow of the water and the second at right angles thereto. Sufficient riprap to sink the mat was then placed, this being estimated at ½ cu.yd. per 100 sq.ft. of mat.

The next step was to cut and place the wire fabric the right length to extend from the outer edge of the mat to the top of the bank. This was then sewed through the rock and brush to the lower layer of fabric with two No. 12 wires spaced 2 ft. in each direction and tightened by twisting with a hook. The sewing of the strips of fabric and the placing of the tie wires are shown in Fig. 3.

On the bank, upstream from the mat boat, were placed several deadmen, to which the upper end of the mat was tied with a number of galvanized-wire strands. The mat boat was then pulled from under the mat by a line fastened to a deadman on the shore and a capstan on the

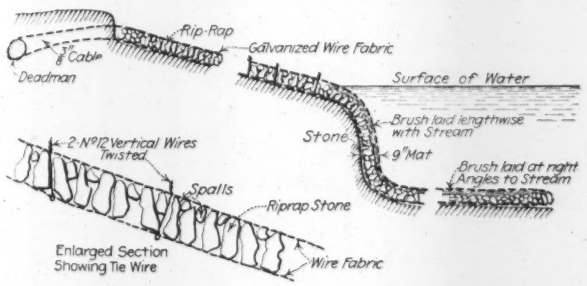


FIG. 2. NEW TYPE OF BANK PROTECTION MATTRESS
Invented by A. O. Cunningham, Chief Engineer, Wabash R.R.

mat boat. The mat made on the barge projects up on the bank, so that the mat above the water level can be sewed to it, making in this way a continuous mat from the top of the bank out into the water about 70 ft. The mat on the bank was made by laying the wire on the bank, sewing the edges together, laying thereon about 9 in. of rock and then laying the wire on top and sewing this through the rock to the fabric below.

One of the advantages of this type of mat is the fact that the rock is in the mat and not on it. On this account it will hang over a very steep bank without damage to the mat. In the case of the willow or pole mattress used extensively on the river the rock sometimes rolls off and the mat floats enough to turn up the edge and permit the water to get behind or under it.

FIG. 3. SECURING THE WIRE NETTING FOR THE MATTRESS
The man at the left is sewing together the edges of adjacent strips of netting. The man at the right has a device for twisting the vertical tie wires

In this way the protection to the bank is destroyed, and in many instances considerable damage is done by the water cutting the bank. The mat constructed as in Fig. 2, with the rock inside if it, acts like a curtain. Recent inspection of the work done in the spring of 1916 shows that the mat is in good condition. With some modification it is a very desirable type of construction, particularly in swiftly moving water and where there is a steep bank below the surface of the water.

Wire Mat for Emergencies

East of Missouri City, Mo., in March, 1916, the Wabash R.R. found it necessary to stop the cutting of the river bank during a high stage of water in which the velocity of the water was too great to permit the building of a mat. The river was cutting rapidly toward the track, and the ordinary method of stopping the erosion failed. A wire mat was made on the threatened bank, and as this fell into the river the mat settled down with it. When the bank was badly eroded and the mat was hanging in the water some 10 ft. or more, the cutting stopped.

This plan worked so quickly and effectively that when the Missouri Pacific System had a very serious cutting of the bank near Wellington, Mo., its officials used the same type of construction when the usual methods failed. Here it was found necessary in about three weeks to protect some 3,400 lin.ft. of bank at a cost of over $35,000. The wire mat hung over the bank into the river before it stopped the erosion. This protection work, while only of a temporary nature, was successful. Since it was completed, the river has changed its channel, and permanent work may not be necessary at that point for some years.

The construction work for the Wabash R.R. was handled by the Kansas City Bridge Co., which takes contracts for bank-protection work on the Missouri River.

Macadam Is a City Pavement, according to a decision of the Superior Court at Pottsville, Penn., Nov. 7, in a case where the city attempted to collect $50,000 in assessments against abutting property for a new wood-block pavement. According to the state law, only the cost of the original pavement can be charged against abutters in third-class cities. The cost of repairs and repaving must come out of the city as a whole. The judge held that the macadam surfacing was the original paving. The case is of much interest in Pennsylvania, for many cities had planned paving macadamized streets at the expense of the abutting property.

First Tile Sewers in St. Louis Compared to Brick

By Ben Moreell*

SYNOPSIS—Bids asked for either brick or tile, the latter being accepted because of lower cost. Excellent comparison of brick and tile construction.

Bids were taken on Oct. 15, 1915, for the construction of 9,500 ft. of vitrified-clay pipe sewers from 12 to 33 in. in diameter and 2,800 ft. of sewers from 39 to 57 in. in diameter. These latter were to be constructed "either of brick laid in portland-cement mortar or of two-ring segment block made of vitrified tile." The 357 ft. of 57-in. was to be 13 in., or three rings, in thickness if built of brick; the other sizes (39 to 54 in.) were to be 9 in., or two rings, thick. The specifications allowed a minimum thickness of tile sewer varying from 7¼ in. for the 57-in. to 5½ in. for the 39-in. diameter.

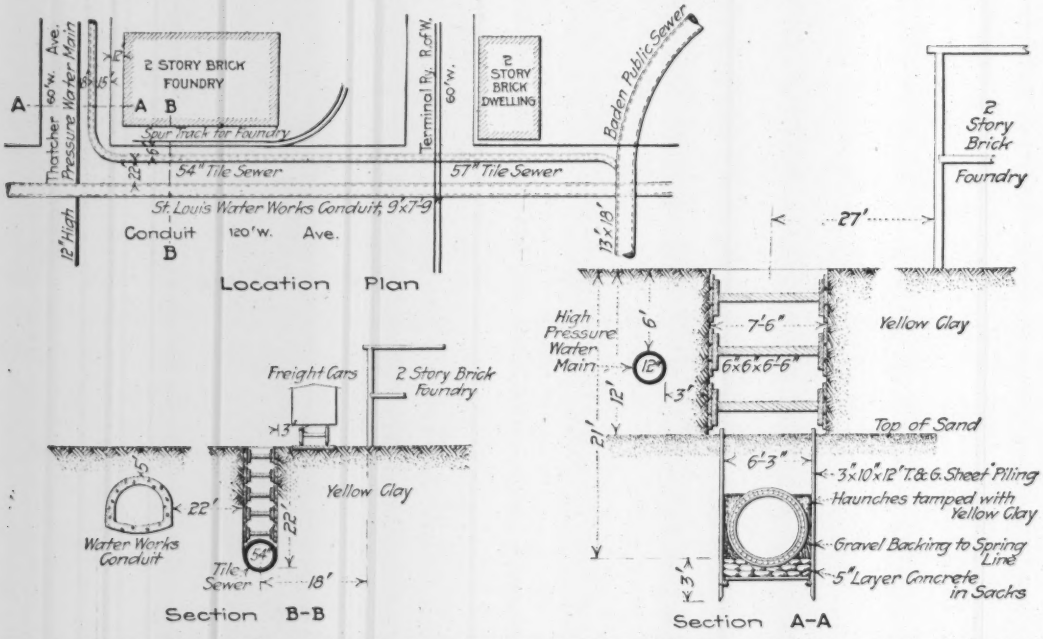


FIG. 1. UPPER—LOCATION PLAN OF TILE SEWER. LOWER—SHOWING TRENCH BRACING IN CLAY AND QUICKSAND

The proposals called for unit-price bids, allowing the contractor his choice of bidding either on the tile sewer and pipe or on brick sewer and pipe. Estimated quantities under both plans were the same except that for the tile sewer a price per lineal foot (for furnishing and laying the tile) was demanded. For the brick sewer the volume of brickwork was estimated and a price per cubic foot of brick masonry called for. A smaller quantity of excavation was estimated for the tile construction because of the thinner shell.

The contract was awarded to the lowest bidder, the George G. Prendergast Construction Co., of St. Louis, which bid on the tile construction. In Table 1 are tabulated the bids of the low bidder on brick and of the successful bidder, only those items which differed in the advertised list of quantities being shown.

It is evident from the table that the cheaper tile construction was the deciding factor in securing the contract. The tile prices listed, however, cannot be taken as representative, as they were undoubtedly influenced by the desire to introduce this new material to St. Louis, this being the first sewer job on which tile bids were allowed. Bids taken on subsequent work were from 10 to 20% higher.

TABLE 1. COMPARATIVE BRICK AND TILE BIDS

Item	Estimated Quantity Brick	Estimated Quantity Tile	Low Bid Brick	Low Bid Tile	Total Amounts Brick	Total Amounts Tile
	Cu.Yd.		Per Cu.Yd.			
Class C excavation	23,700	22,450	$0.65	$0.71	$15,405.00	$15,939.50
	Lin.Ft.		Per Lin.Ft.			
39-in. sewer	415	415	3 11	2 31	1,290 65	958 65
45-in. sewer	405	405	3 50	2 64	1,417 50	1,069 20
48-in. sewer	465	465	3 69	2 97	1,715 85	1,381 05
54-in. sewer	1,160	1,160	4 08	3 30	4,732 80	3,828 00
57-in. sewer	357	357	6 56	4 27	2,341 92	1,524 39
Total					$26,903.72	$24,700.79

The route is indicated in Fig. 1. The outlet is a 13x18-ft. reinforced-concrete sewer. For the first 900 ft. the sewer is located in the water-works conduit right-of-way and is skirted on one side by the 9x7-ft. 9-in. water-works conduit carrying the major portion of the water-supply to the city, and on the other by a large iron foundry, railroad tracks and brick dwellings. The next 1,250 ft. on Thatcher Ave. is made hazardous by the proximity of a 12-in. high-pressure water main 3 ft. from the edge of the ditch.

The contractor made arrangements to use the Ferguson segment block, which consists of an outer heavy ring interlocked by an inner ring of light blocks. The blocks come in 6-, 12- and 18-in. lengths.

*Assistant Engineer, Board of Public Service, St. Louis.

All excavation was removed by means of a clamshell bucket hung from the end of a 45-ft. boom mounted on a bullwheel derrick. The ground encountered on Conduit Ave. was a yellow jointed clay that slacked and peeled after exposure to the air. The trench was braced tightly with 3-in. horizontal sheeting in 20-ft. lengths, using 6x6-in. crossbraces, spaced 10 ft. on centers, as indicated in Fig. 1 (lower left-hand sketch.) All bracing was left in for the permanent protection of the existing structures. On Thatcher Ave. the ground changed gradually from yellow clay to a fine shore sand and quicksand with large quantities of water.

The right-hand drawing in Fig. 1 shows the method of construction in quicksand. The overlying stratum of yellow clay was braced by horizontal sheeting as before, while 3-in. tongued-and-grooved wood sheetpiling was driven through the fine sand and quicksand to a depth 3 ft. below the flow line of the sewer. The piling was of 3x10-in. yellow-pine boards with a ¾-in. tongue-and-groove. A 3,000-lb. Arnott steam hammer operated in a set of double, fixed leads that moved on rollers located on each side of the ditch.

The bottom was excavated in 20-ft. sections, bulkheads being driven across the ditch at the end of each section. The inch flooring was placed as follows: The section ahead of the finished sewer was excavated to a depth 6 in. above the flow line. Two men then began at the low end and excavated a 3-ft. length of narrow ditch along the sheeting for the 2x4 stringers, which were spiked in place. A space was then excavated for a 1x12 transverse board, which was nailed to the 2x4s. After the first 1x12 was placed, the men had a firm footing as they worked forward, flooring the entire bottom.

This construction furnishes a substantial foundation that effectually resists the upward pressure of the quicksand or any tendency to settle when the succeeding bottom is excavated. An attempt to obtain a foundation by packing sacked concrete into the bottom failed, as it was found that when the succeeding section was excavated, the sand would run from beneath the concrete, allowing the entire bottom to settle. Other methods were tried, but none proved so successful as the transverse boards spiked to the sheeting.

A layer of concrete in burlap sacks was placed on top of the flooring, thus furnishing a permanent foundation. The sacks prevented any loss of cement due to bailing water from the bottom and prevented sand from being washed into the sewer.

No attempt was made to pull any of the sheetpiling, and all horizontal sheeting below the level of the 12-in. water main was left in place.

Laying the Tile

The invert was laid in 20-ft. sections except in unusually difficult places, where 10-ft. lengths were used. For the arch, an 8-ft. wooden center with loose lagging for the central 18 in. was used. This allowed the bricklayer to stand in the center and lay tile on both sides up to the quarter-points, and was found to be the most convenient method of operation.

In good ground the invert can be taken out almost exactly to the proper shape. It was found, however, that even under the best conditions it was advisable to use a small amount of gravel to furnish a firm bearing for the outside blocks, which must be laid true to the correct line and grade. Ordinarily the cost of this extra gravel is negligible, as it averaged not more than ¾ cu.ft. per lin.ft. of 54-in. sewer.

Every 50 ft., 6-in. junctions were burnt on the outer block. The inner blocks were cut to fit around the junctions. All reducers were 10 ft. in length and built of two rings of brick. Manholes were built of brick from springline to the surface.

Pipe connections were made by means of 45° slants. No attempt was made to chip the blocks to fit the slant, the spaces between pipe and blocks being filled with brickwork.

Each course in the invert of curves was laid with a wooden templet cut to the radius. The arch was laid with a 5-ft. center, built to the curve.

Brick versus Tile

A comparison of brick and tile construction might be summarized as follows:

Cost—Judging from St. Louis experience, the tile is undoubtedly the cheaper. On all work where alternate bids were taken the tile has been low. The brick manufacturers claim that this has been due to the specification for three rings, or 13-in. of brickwork for all sewers of 60-in. diameter or greater, while the minimum allowable thickness for a 60-in. tile sewer is 7¼ in. The tile manufacturers, however, claim that they can underbid two-ring work with a comfortable margin for profit.

FIG. 2. INTERIOR OF 54-IN. TILE SEWER IN A 22-FT. TRENCH

Strength—A comparative test was recently conducted by the St. Louis Sewer Department. Sections of 60-in. sewer 7½ ft. long—one of tile 7¼ in. thick, the other of two-ring brick 9 in. thick—were buried in the ground and the haunches well rammed up to the quarter-points. Load was then applied through a sand cushion, the loaded area being 4 ft. along the axis of the sewer by 3⅓ ft. wide.

Both sections showed an initial crack at almost exactly the same load, 57,000 lb. total. The load was then increased to 116,000 lb. Under this loading, both sections were badly cracked, although the tile was in the worse condition and showed indications of collapse. Three days after the last load had been placed, the tile collapsed. The brick was allowed to stand for a week longer; then as it showed no sign of failing, the load was removed.

Readings of the deflection at the center and both ends were taken throughout the test. Judging from these readings and the nature of the cracks which appeared, it

seems probable that the entire length of the section acted as a unit in resisting the loading, although only the central 4 lin.ft. was actually loaded. Under this assumption, the first crack appeared at a load of 7,600 lb. per lin.ft., which corresponds approximately to a fill of 17.3 ft. over the top of the sewer in damp yellow clay. ("Theory of Loads on Pipes in Ditches," Marston & Anderson.) The load on the test sections, however, was applied over a width of 3⅓ ft. Marston, however, concluded from his experiments that the load due to ditch filling should be considered as evenly distributed over the top quarter of the arch, in this case a width of 4.4 ft., so that the test no doubt gave more severe conditions than would be given by a 17.3-ft. fill. The 57-in. sewer was built under a fill of 18 ft. and has shown no signs of cracking.

The crushing load of 116,000 lb. is greater than would be provided by a fill of infinite height, according to Marston, indicating that there is small chance of collapse due to the weight of the backfill alone.

Durability—The durability of any material can best be judged by observation under an extended period of service, which precludes a definite opinion of the tile. Judging from the smoothness of the interior, the small number of joints and the imperviousness to chemical action, one would conclude that the tile is at least equal to the brick in this respect.

Leakage—Tile construction depends for its watertightness on the mortar joints between the outer and inner blocks. Unless particular care is taken with this joint, small openings will be left, allowing groundwater to enter. The writer has had some difficulty from this source and recommends that this matter be given special attention. Brick construction is open to the same criticism, but the bricks are more easily handled and can be thoroughly bedded in the mortar. Bricks, being rough and porous, form a better bond with the mortar.

The decrease in the joint area and the smoothness of the glazed blocks themselves undoubtedly increase the hydraulic efficiency of the sewer. Whether the increase in capacity is sufficient to be taken advantage of in the design could be decided definitely only by hydraulic tests. The smooth interior will undoubtedly make the sewer more "self-cleaning," affording small opportunity for filth to adhere to the walls.

These observations are drawn from the experience of the writer as resident engineer on the work. Some of the conclusions may be modified after observing the sewer under service conditions.

Repair of the Tres Cruces Dam, Cavite Province, P. I.*

By C. R. Bennett†

The Tres Cruces dam is located 7 km. up the Timalan River from Manila Bay. The present structure was completed in 1886, replacing another of the same type which was washed out in the seventies. It is constructed of large cut adobe blocks quarried on the site, laid in porous lime mortar. This mortar, where protected from atmospheric action, has a high cementing value, but it will absorb water to the extent of about 20% of its weight.

The foundations of the dam rest on solid adobe. This was excavated about 1 m. deep, and a number of trenches parallel with the main axis of the dam were excavated still farther into it. The footing courses were started in these trenches, which not only gave the dam more resistance to seepage of water under it, but also gave it greater resistance to sliding.

The structure was built with a gravity section, but this is so thin in places that additional buttresses on the downstream side and a clay bank on the upstream side had to be added later to make it more stable. One section 13 m. in length is 15 m. high and only 6 m. wide at the bottom. This is immediately against the west spillway and nearly at the center of the dam. A small buttress has now been added.

During the last few years the spillways have been badly damaged, the west one having been completely washed away and the east one about 40% destroyed. Approximately 6 gal. of water per second, or 864,000 gal. per day, determined by weir measurements, have been passing

*From the "Quarterly Bulletin," Bureau of Public Works, Philippine Islands.

†District Engineer, Bureau of Public Works, Cavite, P. I.

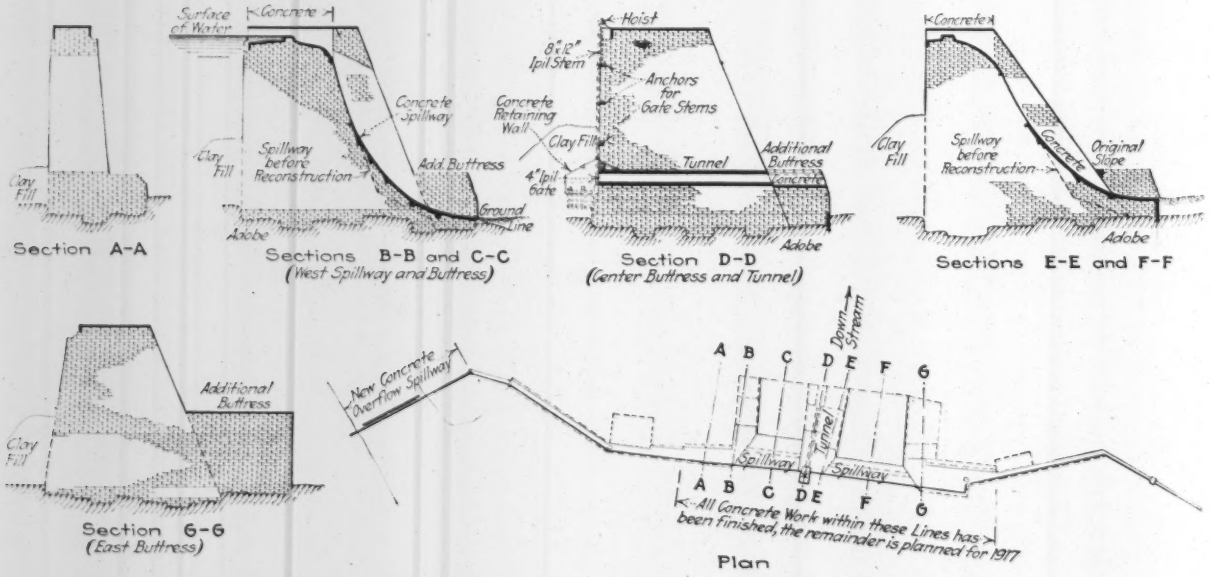


FIG. 1. PLAN AND CROSS-SECTIONS OF TRES CRUCES DAM, CAVITE PROVINCE, P. I.

FIG. 2. TRES CRUCES DAM, SHOWING NEW OUTLET TUNNEL COMPLETED

through and under the dam, taking so much away from the irrigation ditch that something had to be done quickly, not only to preserve the irrigation system, but also to put the dam in a safe condition.

An appropriation of $15,000 was made by the friar lands division of the Bureau of Lands, and the Bureau of Public Works was requested to make the necessary repairs. Work was commenced in December, 1915.

A Tunnel To Let the Water Out

To stop the leaks showing in the face of the dam, it was necessary to let the water out; and as no gate had been provided, a tunnel had to be excavated through the structure. This was located at the original stream-bed center.

Clay had been placed by the builders, on a 1:1 slope, 5 m. high, on the upstream side of the dam to prevent excessive seepage through and under it, and the elevation of the tunnel was made such that the top of it when holed through came just 3 m. from the nearest surface of this clay bank. It was believed that the clay would withstand the pressure of a 46-ft. head of water (20 lb. per sq.in.) long enough to allow the workmen to escape after they had excavated through the dam masonry into the clay.

The tunnel excavation was made 1.6 m. in diameter and was lined with concrete to leave an opening 1 m. in diameter. Three 8-hr. shifts were employed, consisting of four men each. The adobe and lime mortar were so tough that never more than 1 lin.m. was completed in 24 hr. The heading was kept 2 m. in advance of the cement lining, which was placed in 3-m. sections; and the tunnel was completed at the rate of 60 cm. per day. It is just 18 m. long and required one month to complete.

When the excavation reached the end of the adobe on the upstream side and the laborers had put their picks into the soft clay, they required no instructions as to their course of action if water started seeping through the heading—they simply flew, leaving picks and bars. This was at 9:40 p.m. on Sunday night, and at 2:30 p.m. on the Monday afternoon following, the water broke through and shot out 40 ft. below the dam before striking the ground.

It took just 48 hr. to drain the basin down to the natural inlet flow, which amounted, during the whole dry season, to a stream 1 ft. deep on the bottom of the 1-m. diameter tunnel. This, however, is only one-third of the amount of water flowing into the reservoir, for another stream 2 km. farther up is dammed and its water delivered through a 300-m. tunnel to the Tres Cruces reservoir. During the repairs to the Tres Cruces dam, this supply was bypassed over the other dam by closing the tunnel.

Hundreds of natives gathered around with nets and baskets to catch the fish as the water drained out. It is estimated that at least 4,000 lb. of fish and several hundred eels, some 6 ft. long, were caught.

Repairing Face of Dam

After the dam was unwatered, a trench 1.5 m. deep was excavated in the clay bank on the upstream side and the whole of that face repointed. Every seam and joint was cleaned out to a depth of 5 cm., and a 1:2 cement-and-sand mortar was used for repointing them. Numerous holes were encountered below the water line, some requiring several bucketfuls of grout—28 in one case—to fill them.

A large worm-gear hoist of 6 tons' capacity was installed. A gate was built at the upper end of the tunnel, made of 4-in. ipil timbers and brass bound. A heavy brass-bound frame matching the gate was fitted into the face of the dam by excavating in the adobe, after which a rich concrete mixture, 1:1½:3, was poured in to fill the space around the frame and to connect it with the concrete lining in the tunnel. The gate opening is 75 cm. square.

Considerable trouble was encountered in making a tight closure, but this was remedied by wedging the gate up tightly against the frame and then calking around the edges from the tunnel side. After the water had risen to an elevation of 30 ft. above the gate, it was hoisted to release the wedges and burlap calking and then immediately lowered into place. It sealed the opening absolutely—not one drop flowing through. With this head the total pressure on the gate (which is 1 m. square over all) was about 10 tons.

One large additional buttress was built between the two spillways and one at the west side of the west spillway, using 30x30x80-cm. adobe blocks and a 1:4 mixture of cement and sand for mortar. About 6,000 blocks were used in these buttresses. About 3,000 more blocks were used in building up the ogee surfaces of the two concrete spillways. Round reinforcing bars of ⅜-in. diameter were used in the concrete surfacing on each spillway, spaced 60 cm. c. to c. both ways, and ½-in. square twisted dowel pins were driven 20 cm. into the adobe at each bar intersection, the reinforcing being wired to these dowels.

Waterproofing Old Dam

Ample provision has been made to carry away any seepage through the dam, liable to be caught behind the concrete, by the use of tile and steel pipe. At the location of the large leak, a trench 1 ft. square was dug the full width of the spillway, filled with 2-in. gravel, and from this a 5-in. vitrified-tile drain was led under the con-

crete to the downstream side of the curtain wall at the end of the spillway. In addition, every 2 m. along the vertical length of each spillway a 6-in. square trench was excavated and filled with large-size gravel, and every 2 m. a 2-in. galvanized-iron pipe was led out flush with the concrete surface of the spillway floor.

A strong curtain wall was built across from the two buttresses at the outside edge of each spillway, and the concrete was butted up against it. It is 1½ m. deep into solid adobe in the stream bed and is 50 cm. thick. All downstream joints in the masonry were repointed.

An additional spillway was provided at the extreme west end of the dam by constructing a concrete curtain wall from the end of the dam across a natural depression and anchoring it into a high bank on the opposite side. This spillway section is 18 m. wide and is built so that when the water exceeds 1 ft. in depth on the crest of the main dam spillways it will flow over the new one, which will take care of a great deal of flood water. This depression leads away from the dam, and being in solid adobe, can never cause any dangerous scouring around the end.

The total cost for repairs has been approximately as follows:

Materials, Bureau of Supply and local	$6,945
Payrolls and salaries, including 3.75 km. of road construction	3,947
Miscellaneous expenses, transportation, traveling expenses, etc.	2,205
Provincial surcharge, 5%	530
Bureau of Public Works surcharge, 10%	1,363
Total	$14,990

Imhoff Tanks and Sprinkling Filters, Cleburne, Tex.

By R. E. McDonnell*

SYNOPSIS—The design of the Imhoff tanks is shown with unusual fullness, both as to arrangement of parts, and the concrete reinforcement.

From a haphazard sewerage system and an old-type septic tank privately owned, Cleburne, Tex., with a present estimated population of 14,000, has recently changed to much more extensive and well-designed municipally owned sewers and disposal works, the latter consisting of Imhoff tanks, a dosing tank, sprinkling filters, secondary tanks and sludge-drying beds. This change was preceded by the acquisition, improvement and extension by the city of the privately owned water-works. A private water company accepted the valuation placed on the plant by the engineering firm employed by the city, but the sewerage company refused to do this.

*Of Burns & McDonnell, Consulting Engineers, Scarritt Building, Kansas City, Mo.

The effluent from the old septic tank caused a nuisance in Buffalo Creek, a stream with a dry-weather flow so small as not to provide dilution of the tank effluent collected by about 10½ mi. of sewers.

In designing the new disposal works, which at the outset will treat sewage from 33 mi. of sanitary sewers, the writer's firm was confronted with the drastic Texas law of 1913 and 1915, published substantially in full in *Engineering News* of May 25, 1916, page 980. It was assumed, however, that the State Board of Health would interpret the law to meet local conditions. Since the waters of Buffalo Creek are used only for livestock purposes for a long distance below Cleburne, it was decided to install Imhoff tanks, sprinkling filters and final settling basins. From gagings and observations made on the flow in the present sewer system and from the records of the daily water consumption the plant was designed on a basis of 800,000 gal. per day, with provision for a 50% increase when necessary.

FIG. 1. GENERAL VIEW OF SEWAGE WORKS OF CLEBURNE, TEX.
Imhoff tanks and sludge beds at right; sprinkling filter at left

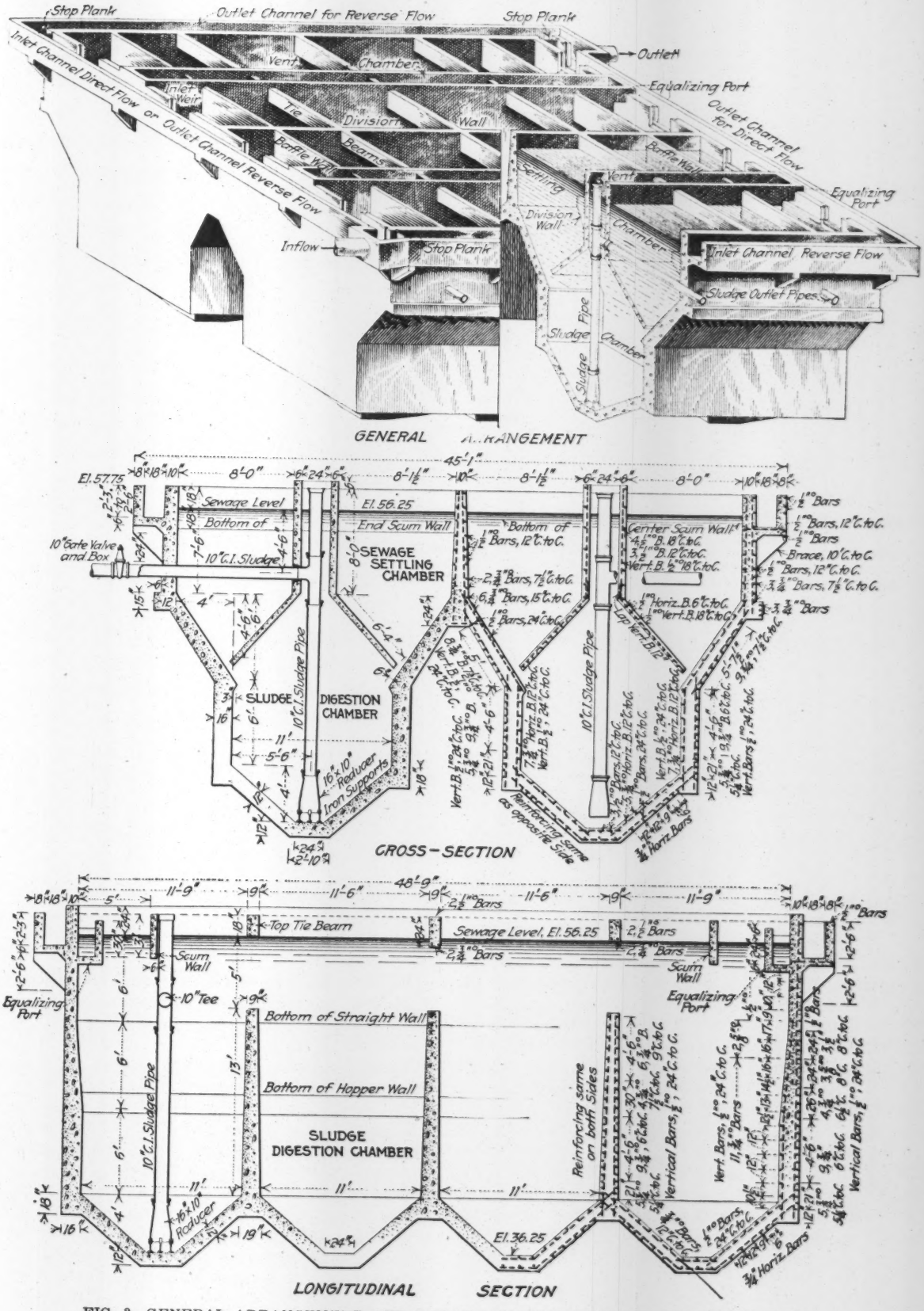


FIG. 2. GENERAL ARRANGEMENT AND DETAILS OF IMHOFF TANKS, CLEBURNE, TEX.

FIG. 3. SPRINKLING FILTER, CLEBURNE, TEX.

The Imhoff tanks (Figs. 1 and 2) are in two units, so that one-half may be cut out of use at any time. Each tank is 19 ft. 1 in. wide by 48 ft. 9 in. long and 22 ft. deep from sewage surface to bottom of sludge chamber. The flow chambers are designed for a 2-hr. retention period, based on an hourly rate of one-eighteenth of the average daily flow. The sludge chambers have a combined holding capacity of about 8,000 cu.ft., sufficient for 3½ months at maximum capacity.

The gas vent is 24 in. wide and extends the full length of each tank. It is formed by continuing the hopper walls 30 in. above the normal sewage level. Equalizing ports are provided to prevent any flow of fresh sewage through the digestion chamber due to any difference in outlet weir elevation or unequal flow into the chambers.

The sewage enters the controlling channels at one corner, flows into the tanks through ports 30 in. wide, two for each tank, and out through similar ports provided with sharp-crested weirs formed by removable iron plates. The ports used as inlets will have a depth of about 6 in. below the sewage level, allowing free passage of floating particles. In reversing the flow a 5-in. iron plate forming the outlet weir will be transferred to the opposite end, thus transforming the outlet to inlet ports. A concrete channel is carried around the outside of the tanks and provided with stop planks so arranged as to reverse the flow by adjustment of the planks and port openings. The tanks are provided with concrete scum walls, located 5 ft. from each end and extending 18 in. below the sewage level.

Each sludge chamber is provided with a 10-in. cast-iron sludge pipe, terminating in a 10- to 16-in. increaser. The outlet pipe is located 4½ ft. below sewage level.

The two 25x50-ft. sludge beds consist of 6 in. of sand on 6 in. of graded gravel over 6-in. tile underdrains, 8 ft. c. to c. The beds were designed to receive approximately 2,500 cu.ft. of sludge at one draw. As the climate is moderate, the sludge digestion will be fairly active the whole year, as the sludge storage and sludge-bed capacity is not as large as would be required in a colder climate.

The tank effluent flows into a tapered dosing tank and is discharged by an 18-in. siphon to the filters. When operating under the rated capacity of the plant, the siphon will discharge about every 6 min.

The sprinkling filter (Fig. 3) covers an area of 0.326 acres and is designed to treat sewage at the rate of 2,225,000 gal. per acre per day. The depth of the stone forming the filter medium averages 5½ ft. The floor of the beds consists of a 4-in. concrete slab on top of which are set 6-in. half-tile drains, 9½ in. c. to c. The floor has a slope of 1 to 40 to the main outlet drains. The upper ends of the 6-in. half tile are connected into a concrete box channel. The main outlet channel is provided with 8-in. vitrified-pipe vents spaced at regular intervals, topped with vitrified elbows that turn with the wind.

The main distributor line consists of a 24-in. vitrified pipe incased in concrete extending through the center of the filter bed. The lateral distributors are 8-in. vitrified pipe, 11½ ft. c. to c., cased in concrete. The risers, also 11½ ft. c. to c., consist of 3-in. galvanized-iron pipe, connected into vitrified tees. The nozzles are of the square-spray type.

The outside walls of the filter beds are of concrete, 6 in. thick, and are not designed to be self-sustaining, but to act as a division between the earth and the stone filter medium. The specifications provide that the earth-fill and filter rock shall be deposited at the same time, keeping the overturning forces counterbalanced.

The effluent from the filters passes into a secondary settling tank, having a 1 hr. retention period, before finally discharging into Buffalo Creek. This tank is about 21 ft. wide and 40 ft. long, with a sewage depth of 5¼ ft. at either end and 7 ft. in the middle, and a drain channel extending from either side to a central gate at the end of a sludge pipe.

The relative elevations of the various components of the plant are as follows: Sewage level in Imhoff tanks, 56.25 ft.; high water in dosing tank, 56; low water, 51; top of filter stone, 48; outlet drain from filters, 41.1; sewage level in final settling tank, 40.75; ordinary water level in Buffalo Creek, 30.5; top of sludge bed *A*, 50; top of sludge bed *B*, 48.5 ft.

The waste excavation will be graded around the plant to El. 49 to protect all parts from high water, which lasts but a very short time. High-water mark is at El. 47, but the water rarely reaches this elevation. Provisions are made for bypassing the tank effluent and the filter-bed effluent directly to the creek.

The improvements were started and made possible through the untiring efforts of Mayor C. W. Breech, who was well supported by a live, progressive council. Bids were received June 4, 1915, on 33½ mi. of sewers and the disposal plant. Hamilton Brothers Construction Co., of Houston, Tex., was awarded the contract for all the work at $144,527, of which the disposal plant amounted to $28,194. Plans were prepared and the construction work was supervised by Burns & McDonnell, Consulting Engineers, Kansas City, Mo., who also made the appraisal of the water and old sewer systems and plans on the water-works improvements. The plant is now in operation.

Unusual Slide of Canal Lining and Its Repair

[CONTRIBUTED]

SYNOPSIS—In September, 1915, the lining of a third of a mile of canal extension in the hydro-electric development of the Turners Falls Power and Electric Co., on the Connecticut River, slid into the bottom of the canal. These notes on the original construction, the slide, the probable causes and the methods of reconstruction have been contributed on request by the various engineers connected with the work.

It is commonly known that a slide of power-canal banks occurred at Turners Falls, Mass., on Sept. 10, 1915. Behind that accident, and in the repairs to the canal lining (for the protecting lining was all that failed), lie matters of interest and importance to the engineering profession which it is now useful to disclose. The following paragraphs describe the original construction and the slide, and discuss the probable causes of the failure and the methods used in reconstructing the canal linings.

ORIGINAL CONSTRUCTION

The main features of the hydro-electric development of the Turners Falls Power and Electric Co., on the Connecticut River at Turners Falls, Mass., consisted of the enlargement of an existing power canal and its extension for a little over 1½ mi. downstream to a new power house utilizing the full local fall of 58 ft. and having a rated capacity of 36,000 kw. A general description of this whole development appeared in *Engineering News*, July 29, 1915.

For a length of approximately 1,800 ft. at the upper end of the canal extension, where the width on top was limited by houses and streets on one side and the railroad right-of-way on the other, the excavation was for a slope of 1 on 1½ with an average total depth of cut of about 40 ft., and a depth below water line of 26 ft. This slope was lined with riprap extending from an elevation 3 ft. above water line to 18 ft. below water line, the upper 14 ft. being of a uniform thickness of 18 in. for the 1 on 1½ slope; below this the surface of the riprap was sloped at 1 on 2 for a vertical height of 7 ft., thus making it 3.3 ft. thick at its base. At this point it rested on a toe of gravel fill sloped 1 on 3 for a height of 4½ ft., 1 on 6 for a height of 2½ ft. and then 1 on 1½ for the remaining foot to the bottom of the canal. At all places where there was very fine sand or clayey material there was an underlining of 18 in. of gravel underneath the riprap to prevent the water carrying the fine sand out through the riprap while emptying the canal. Fig. 7 shows a section of the original construction.

Downstream from this restricted section the canal was continued with a wider cut for a distance of 1,100 ft., the sides sloped at 1 on 2 with no 1 on 1½ slope. With this exception, the lining was made the same way. At the end of this cut the canal broadens out to a forebay pond with embankments on each side sloped 1 on 3 and lined with 18 in. of riprap.

The riprap consisted of stone taken from rock cuts in other parts of the canal and varied in size from fairly small chips to stones ½ yd. or more in volume. It consisted chiefly of sandstone and some shale and was in general rather more in flat slabs about 3 to 9 in. thick than of cubical or spherical shape. It was dumped in loose, except that a line of header courses of stones laid on edge was put in at the bottom and every 8 ft. from there up measured along the slope. The method of putting it in, dumping from the top of the bank 5 to 15 ft. above the top of the lining, eliminated the smaller fragments and the dirt which was left on the slope above the top of the lining. Some rehandling of the stone was necessary to make it conform to the lines of the slope, and this probably resulted in many of the thinner stones in places being laid flat on each other, somewhat like shingles on a roof.

The gravel used for the toe and the lining behind the riprap was also taken direct from the excavation. Although it was somewhat finer than the best quality of gravel and carried some dirt, it was for the most part of the same quality as that which was used with good results, without screening or washing, for concrete in the heavy mass work of the retaining walls.

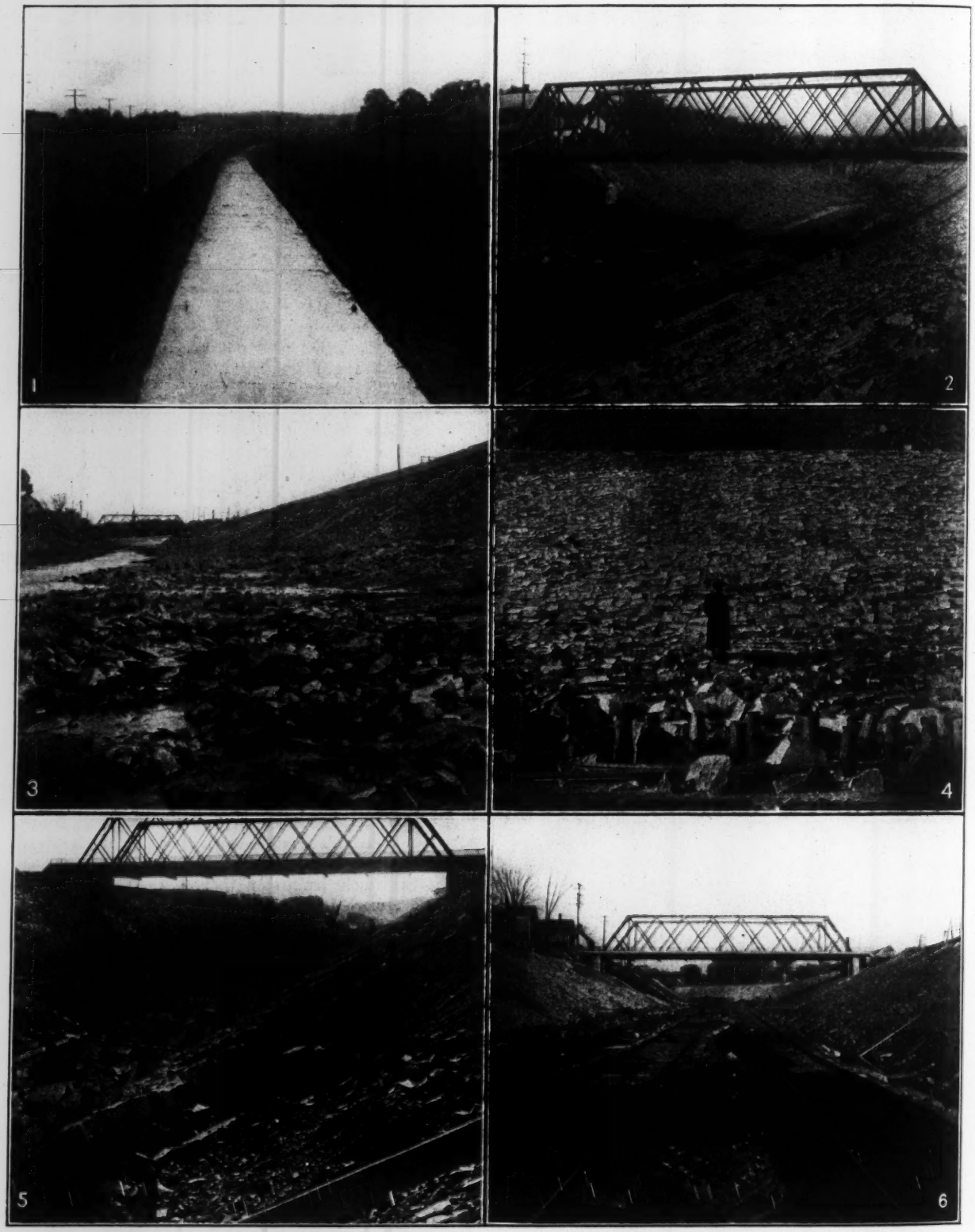
FAILURE OF RIPRAP LINING

On Sept. 10, 1915, nine days after the water had been started into the canal and about 24 hr. after it was up to water line, the lining of riprap and gravel, over a length of about a third of a mile and for practically the whole of that portion of the canal where there was any 1 on 1½ slope, slid down into the bottom of the canal. A short length of about 150 ft. on the west side, where there was natural gravel behind the riprap, stayed in place. The slide started on the west side at the upstream end and within a very few minutes it extended the whole length on that side. The other side followed almost immediately after the west side had started, as if the wave of the first slide initiated it.

For the most part, the riprap with its gravel underlining piled up across the middle of the bottom of the canal, though in some cases it stopped at the foot of the slope without going beyond across the bottom. In a few local places the riprap slid to the bottom of the slope, retaining in general its character of a sheet 18 in. thick. There was very little slipping of the natural earth of the cut behind the lining, the only places where this occurred being where the top of the cut was in fine sand and the natural earth had been excavated to permit placing the 18 in. of gravel behind the riprap. Thus the accident was not in the nature of a "slide," but more a failure of the lining.

CAUSE OF FAILURE

The sliding appears to have been due to three main causes, each of which probably contributed its share: (1) The inability of the riprap, with its somewhat shingly character, to stand at 1 on 1½ slope when lubricated by the water (rough tests of slabs of standstone laid flat



FIGS. 1 TO 6. VIEWS OF TURNERS FALLS CANAL, SLIDE AND RECONSTRUCTION

Fig. 1—The canal on Sept. 1, 1915, looking upstream; showing original construction. The slide extended a little beyond the bend. Fig. 2—Canal on Aug. 2, 1915, looking downstream; showing original riprap on right, and on the left gravel underlining and toe being placed. Fig. 3—Canal on Sept. 11, 1915, after failure of lining; riprap on bottom. Fig. 4—Completed riprap on west canal bank, viewed from middle of bottom; also shows piling in for concrete toe. Fig. 5—Showing west-side concrete toe and paving, and berm on east side; tracks are on unexcavated material of slide. Fig. 6—Reconstructed canal, looking upstream; east side completed, and west side completed except for berm on toe

on each other at random showed a tendency to slide even at a flatter slope than 1 on 1½); (2) the softening and lubrication of the gravel fill behind the riprap, due to the water making its angle of repose less than 1 on 1½ and putting pressure on the riprap which it could not stand—being very near or beyond its own safe slope—or if not putting actual pressure on the riprap at least providing something similar to lubricated ball bearings for the riprap to slide on; and (3) the failure of the gravel toe to hold the bottom of the riprap once it started to move. Different conditions at various points showed that none of these causes was the sole one. There were places where the riprap slid, first where it had a footing on rock, and there was consequently no gravel toe, and secondly where there was no gravel behind it. There were places where it did not slide, or slid only partially, where there was gravel fill behind it. The gravel toe was evidently stable in itself, as it did not slide in the lower part of the canal, though of the same form.

Reconstruction of Lining

The coffer-dam at the upper end of the canal extension had not been removed, and the water was quickly drawn off from the new canal and work was immediately started on rebuilding this portion of the lining. The following plan was decided on for the new construction: On the east side a strip of land 15 ft. wide was obtained from the railroad, which made it possible to slope this side at 1 on 2 all the way to the top. This was not possible on the west side, where it was necessary to maintain the former top of the slope.

On the east side a trench was dug 3 ft. below the bottom of the canal and 6 ft. wide at the bottom. Into this were put very large selected stone with the spaces filled with smaller stone and gravel well compacted to about 1 ft. above grade, making a kind of toe 4 ft. thick. With this toe as a footing, the lining was started, consisting of paving about 15 in. in thickness with the stones laid by hand on edge up to the top. Gravel was spread over this and washed into the spaces with a hose. On top of the toe and extending on the riprap slope a berm of rock and gravel fill 5 ft. high above the bottom of the canal and 22 ft. wide was made to give added weight to the toe. In places where the original material had slid the holes were filled to the back of the riprap with gravel and stone and well compacted with water.

On the west side the same general form of construction was adopted except that in the toe trench after the large stone had been placed, a mat of concrete was put in to a height of 18 in. above the bottom grade, thus making a footing of concrete and large stone 12 ft. wide at the top and 4½ ft. thick. On this footing the paving was laid of stones on edge, in no case less than 18 in. thick. Places where the original materials had slid beyond the original excavation lines were also filled with stone (except those near the top of the slope), so that in general the lining on this side was thicker than 18 in. The berm on the toe at the bottom was built of the same width as on the east side, but 3 ft. higher. Over the paving was spread 9 in. of gravel, which was left to be carried into the spaces between the stones by the water when the canal was filled.

For a length of about 500 ft. where the bank consisted of very fine and clayey sand, two lines of 20-ft. and 25-ft. piles were driven in the toe trench, the tops extending about 3 ft. through the concrete toe, the large stones being placed in among the piles before concreting.

The general method of doing the work was as follows: A steam shovel cut was run through the bottom of the canal at the bottom of each slope, taking out to grade the material which had slipped in, leaving a berm in the middle. This material was used either for paving where possible, or for filling in behind the paving or in the berm and toe. The trenches were dug with orange-peel buckets by locomotive cranes following the shovel. Other cranes put in the large stones which were excavated by derricks and a steam shovel from the main rock dump. The paving on the east side was secured also from the rock dump, but as the season advanced and frost interrupted, quarry waste was purchased for the paving from nearby granite quarries at a cost less than that of excavating it from the dump. The west side thus came to be lined with granite blocks, making an excellent paving. After the sides were well up, the material from the middle of the canal was excavated by steam shovel and deposited directly in either berm, together with other material taken from the dump.

It was decided that it would be advisable to make certain that there would be no future possibility of trouble from the gravel toe at the foot of the 1 on 2 slope of the downstream portion of the cut, where there was no sliding. Accordingly, these gravel toes were removed and replaced with paving resting on a small concrete toe

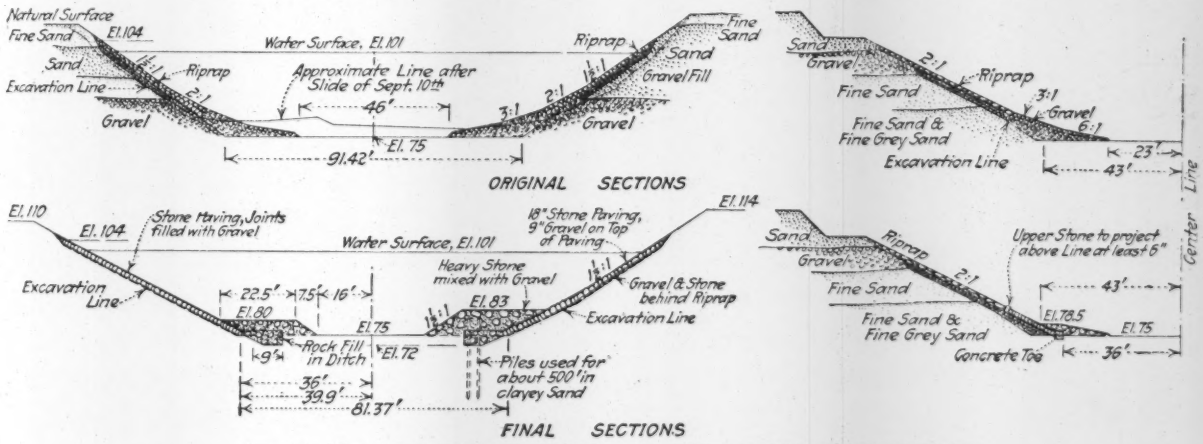


FIG. 7. OLD AND NEW SECTIONS OF TURNERS FALLS CANAL BANKS

in a shallow trench along the bottom of the slope. A small berm 3½ ft. high and 13½ ft. wide was made over this concrete.

This work was completed and the water started in again on Jan. 1, 1916, the canal being filled to the water line on Jan. 28. Since then soundings and observations show no perceptible movement of the lining, with the exception of a very slight settlement of the berms on each side.

Probably the lesson to be learned from this failure is that the earth slopes of large and deep canals, which must be designed to withstand varying currents and changes in the elevation of the water from a full to a completely empty canal, as well as the ordinary wear and tear due to frost, ice, etc., present problems in which not only the changing qualities of the natural earth at the sides of the canal but of the materials used for lining have a very important bearing upon design and construction.

When there is ample space, economy generally dictates the use for large canals of slopes so flat as to afford security against slipping, and in this case proper designing of linings to resist wear and tear is not difficult. When the space is limited so that steeper slopes must be adopted, economy may still dictate the use of slopes instead of walls, but the engineering problem becomes more difficult. The lining must be designed not only to be stable in itself, but so that it will add to the stability of the earth slope on which it rests.

The available information upon which to base designs of linings for securing stability of steep slopes at a low cost is rather limited. It is hoped that the discussion of this failure may add knowledge on this subject. In this case the final construction was entirely different in character and in consequent expense from what was originally attempted; the failure might have been avoided if similar experiences had been on record.

Complex Grade Changes in a Highway Bridge

A heavy street bridge with complex grade conditions has been built by the City of Pittsburgh on Herron Ave. over the Baltimore & Ohio R.R. tracks, on account of the elevation of the tracks at this point to eliminate a grade crossing at 33rd and Liberty St. Formerly, there was a pin-connected deck truss bridge at this point. The new bridge is an 118-ft. riveted pony truss span with concrete-incased floor.

The span is skewed at both ends. This fact, in connection with the flattening of grade on the span from the steep approach grade on either side, results in the break of the grade on the bridge. One of these shows in the truss outline. Further, the approach roadway being flat transversely and the roadway on the span crowned, there is a transition section just beyond either end floor-beam of the bridge. The crown transition and the changes in grade do not coincide.

Part of this situation was caused by the fact that after the ordinance grade line had been fixed, it was

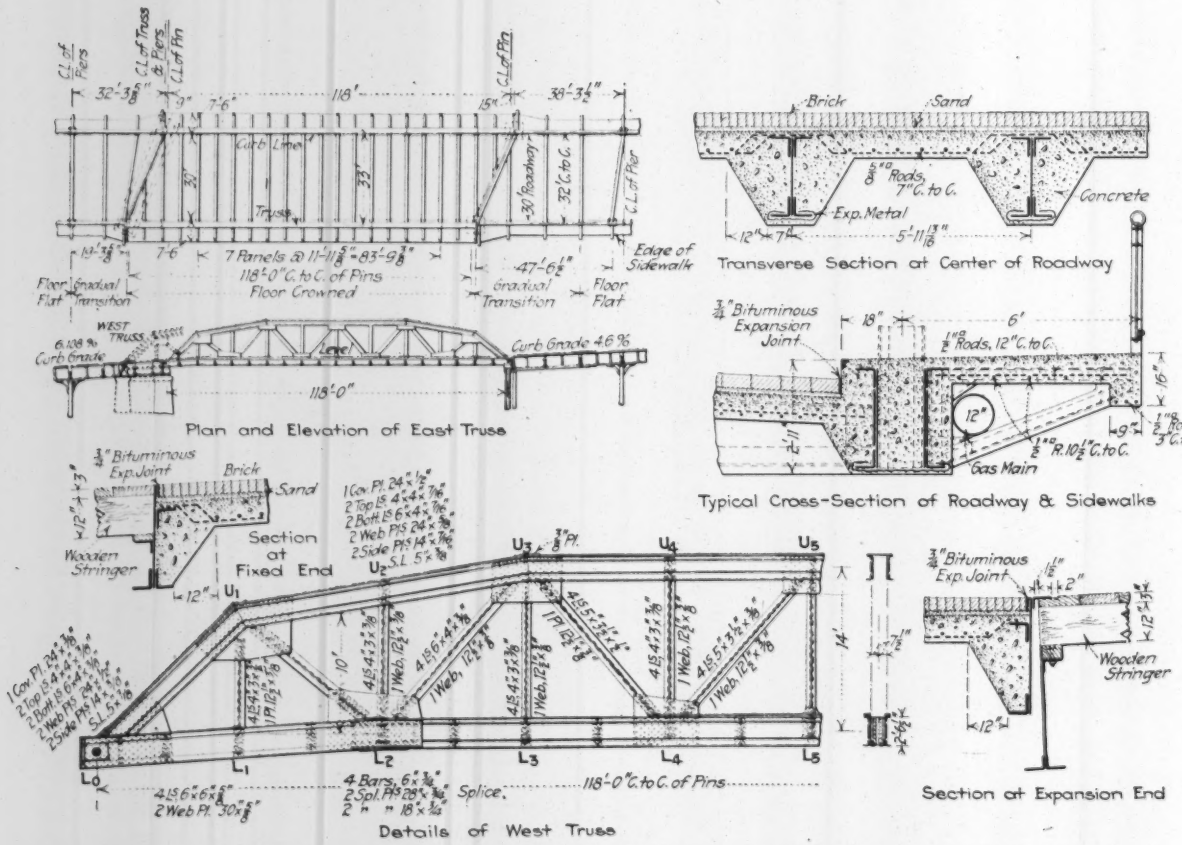
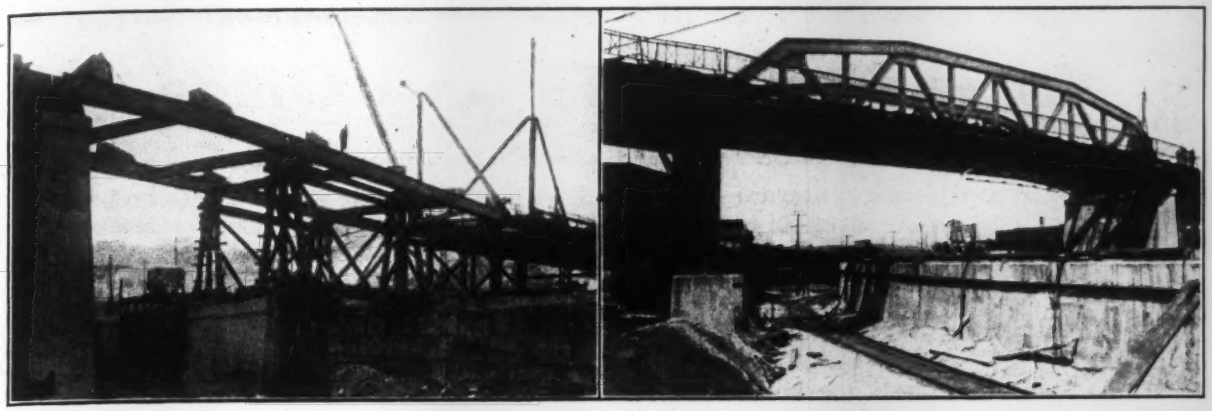

Plan and Elevation of East Truss
Transverse Section at Center of Roadway
Typical Cross-Section of Roadway & Sidewalks
Section at Fixed End
Section at Expansion End
Details of West Truss

FIG. 1. DETAILS OF HERRON AVE. BRIDGE OVER B. & O. R.R. TRACKS AT PITTSBURGH, PENN.



FIGS. 2 AND 3. HEAVY 118-FT. TRUSS BRIDGE OVER B. & O. R.R. TRACKS, HERRON AVE., PITTSBURGH

decided to lengthen the span. Leaving the grade of the span the same and shifting the foot of the approach to the new end of the span would have made the approaches steeper. One approach was already on a 6.1% grade, and therefore the grades were left undisturbed and the break made within the length of the span.

Both the grade and the crown transition are shown in the drawings herewith. The detail elevation of one end of the bridge brings out clearly how the situation is affected by the skew of the bridge and the fact that the break in grade necessarily is at right angles to the center line of the street.

Very complete protection against corrosive locomotive gases has been provided. The floor is shallow; steel floor-beams spaced about 6 ft. apart support a reinforced-concrete deck which carries brick paving. The incasement of the floor-beams was detailed so as to permit thorough working of the concrete and effective attachment of the concrete layer under the beam. Floor laterals are omitted, in view of the bracing furnished by the floor concrete, which is unusually heavy.

The span contains 3,200 lb. of steel per lineal foot and the entire dead-load weight is 13,600 lb. per lin.ft.

In constructing the new bridge in place of the old the girder approaches were in large part retained. As the new floor level of the span is about 4 ft. above the old, however, it was necessary to raise the approach columns by varying amounts. This was done by increasing the pedestal height, except where the columns were built into a building, as occurred in the south approach. In this case jacking beams were bolted to the columns at the top, the girders raised, and short lengths of columns spliced on. It had been expected that it would be necessary to provide beveled plates at the tops of the columns because of the increase in floor grade, but it was found that in most cases the old columns were so badly out of plumb that the change of angle merely made them more nearly vertical.

On account of the skew of the bridge it was not possible to provide expansion by supporting one end on a rocker bent. Instead, a fixed steel bent had to be provided and expansion bearings placed upon it. This bearing is equipped with specially designed self-locking rockers to prevent tipping in case of over-expansion, as illustrated in *Engineering News*, September, 1916.

Robert Swan is Director of Public Works, N. S. Sprague, Chief of the Bureau of Engineering, and T. J. Wilkerson, Division Engineer of the Division of Bridges, in charge of design and construction.

Illinois Engineer Corps on the Mexican Border

Interesting information as to the work of Company A, Illinois Engineers, with the troops on the Mexican border is given in the September number of the "Journal" of the Western Society of Engineers (Chicago). This company was called out June 18 and left for the mobilization camp at Springfield, Ill., on June 20. On July 4 the men were mustered into the service of the United States, and (with the Illinois Signal Corps) entrained for San Antonio, Tex., where they arrived July 7.

The first work given them was to design and build a drainage system for the entire camp. The designing and superintendence of this were done by the men of Company A, and the labor was performed by civilian laborers. Culverts were built at all road crossings.

The company was divided into four sections—the Reconnoissance Section, the Bridge Section, the Demolition Section and the Fortification Section. The Reconnoissance Section made a complete survey of the entire camp and a detailed contour map showing the location of all buildings, etc. At New Braunfels a lieutenant and 10 men of the Demolition Section laid out a complete brigade camp.

The next important work was the making of a map from San Antonio to Austin, 85 mi., the map covering one mile on each side of the road. This was done by the Reconnoissance Section, it being divided into four parties, each equipped with motor trucks, automobiles, motorcycles and horses.

The company roster shows that over one-third of the men are technical graduates, and nearly every man has had considerable engineering experience. Ever since the company has been in camp, they have been going on a "hike" each morning before the regular work of the day begins. Each afternoon, when not on special work, two hours' instruction is given to each section. Four men from the company have been authorized to take the examination for second lieutenant in the regular army. Company A is not attached to the Illinois troops, but is under direct orders of the division headquarters and may be assigned to duty wherever the commander may desire.

Notes from Field and Office

Mixer charged by two bucket conveyors—Three methods of surfacing loose sandy soil—Five ways to waterproof drawings—Errors in new type of precise level—Steel transfer plate for muck-cars, instead of switch—What a Mississippi flood can do to a pipe-laying job—Cutting up steel stacks and heavy machinery

Bucket Conveyors Feed Mixer

A conveyor-fed mixing plant, in use in the construction of a four-story addition to the Hume-Fogg High School at Nashville, Tenn., permits rapid charging of the mixer and reduces the force required at the feeding end.

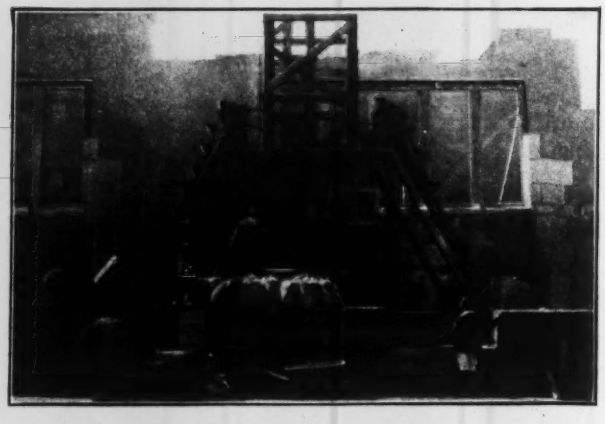


FIG. 1. SHOWING CONVEYORS LEADING TO MIXER

One bucket conveyor is used on each side of the mixer, each descending into a pit, which is surrounded by a bulwark. There is a gate in the bulwark, against which the material—the sand on one side and the gravel on the other—is dumped from motor trucks. On raising the

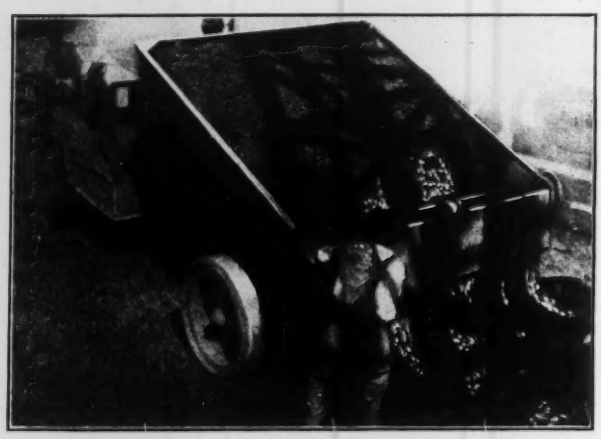


FIG. 2. FIVE-TON TRUCK DUMPING STONE AT SITE

gate, the material slides steadily into the conveyor. It is carried to a storage bin, 14 ft. above the ground, partitioned to hold 5 cu.yd. of gravel and 3 cu.yd. of sand. This is fed through hoppers to measuring hoppers from which the mixer is charged. The feed has a capacity considerably beyond that of the mixer.

One 6-hp. vertical engine is used to drive the conveyors, one being belt-driven and the other being driven by a connecting sprocket gear above the bin. The mixer is driven by a similar engine, there being a central steam plant.

Two men are used for light shoveling on the gravel pile and one man on the sand pile. One man controls the material hoppers and another is required to discharge the batch. An engine runner and fireman work on both the hoisting engine and the boiler for the other engines. The equipment used in rigging the plant was old machinery, and the entire cost is figured at $100. Two 5-ton motor trucks, each delivering a load from the material yards about 1¼ mi. away, in about 30 min., operate continuously.

The contractor is the Foy-Proctor Co., of Nashville, and the plant was devised by the superintendent, Gordon Jones.

⁂

Good Road Surfacings for Loose Sandy Soils

[CONTRIBUTED]

The following is a description of a broken-stone macadam road 16 ft. wide and over 3 mi. long, built on loose sandy soil. The stone used for the bottom course was 2½ in. in size and averaged about 5 in. in depth. Care was taken not to trench and not to prepare any more subgrade than could be covered with a day's run of stone.

The shoulders were kept high and were not trimmed until the stone in the road had bonded together. The top course was an asphaltic concrete of gravel and binder, mixed hot, and averaged about 2½ in. in depth. The crown of the road was 3 in., and the shoulders had a drop of 10 in. in their width of 8 ft.

Rolling was done with a 10-ton steam roller of the three-wheel type. By working the roller forward, the front wheel was used to compact the loose stone in advance of the heavier back wheels. On a 300-ft. stretch of particularly loose sand, logs were buried in the shoulders to hold the macadam from spreading.

Extraordinarily heavy hauling was done over the bottom course. Because the work was started at the point nearest the base of supplies and carried forward, hauling was done over all new work. The top course was started at the end of the prepared bottom course and worked back toward the beginning. Two Buffalo-Pitts traction engines and eight stone cars of about 5 cu.yd. capacity each constituted the outfit for hauling all materials, which were brought by boat to within 1½ mi. of one end of the job.

The bottom course stood the strain of two winters and all the hauling and did not require any repairs before

applying the top. It held its shape so well that it looked like a completed top course when finished.

It would seem that a good road can be obtained over sandy soil by using broken stone filled with limestone screenings and puddled, with a cold-oil and fine-gravel cover wearing course. The cost of such a road will depend upon available materials.

Another example of a road constructed over light sandy soil is one that runs for a considerable distance along the lee of sand dunes and is built of loam. This is an inexpensive and at the same time durable type of road for light traffic. When weathered down, it is shaped and oiled at small expense.

At the present time there is under construction a road 1 mi. in length over sand dunes, cinders alone being used for road metaling. They are placed about 1 ft. in depth by 14 ft. in width. This road is across Nepeaque Beach at the eastern end of Long Island and will make Montauk Point accessible to motorists.

How To Waterproof Drawings

By F. W. Salmon*

Referring to C. F. Bell's letter in *Engineering News*, Oct. 26, 1916, let me state that at different times I have found each of the following methods very useful and satisfactory for waterproofing drawings, and I believe that they will serve Mr. Bell's purpose.

A. Give the drawing several light coats of white shellac dissolved in a grain alcohol, letting each coat dry before the next is applied. Orange shellac and even wood alcohol may be used; but I much prefer the "white" or bleached shellac, and I object to the wood alcohol because of its injurious effect on the eyes.

B. Give the drawings several light coats of "Zapan" varnish, which, I understand, is made of scrap trimmings of clear sheet celluloid dissolved in acetone and is produced by several Eastern chemical factories and firms manufacturing celluloid articles.

C. When a heavier protective covering is desired than A or B will provide, the drawing may be made wet with the thin celluloid varnish and pressed down evenly on a sheet of thin sheet celluloid, then allowed to dry. This process gives a beautiful clear mounting with 0.01 in. of celluloid on the face.

D. Drawings may be made waterproof with paraffin wax, which is applied hot (melted) with a flat bristle brush. The drawing is then put between two sheets of blotting paper, and a hot (electric) sad-iron is passed over the upper blotter, thus causing the paraffin to be distributed more evenly and the surplus to be absorbed by the blotting paper. The blotters must be removed before they cool. If the wax is thick and white over any part of the drawing or print, sponge it off with benzine.

E. Drawings may be paraffined by dissolving the paraffin wax in benzine and then thoroughly painting the drawing with this liquid or passing the drawing through a bath and hanging it up to dry.

Some of the solvents mentioned are very inflammable and even explosive, so all open lights should be kept away from them. Sometimes they affect certain people injuriously; accordingly, such work should be done only in a well-ventilated room, with a fan to keep fresh air moving over the work.

*526 North 20th St., Birmingham, Ala.

Bubble-Reading Mirror Proves Source of Error in Leveling

By George Bevier, Jr.*

The merits and faults of surveying instruments form a subject of perpetual interest to engineers, particularly when a discussion of them attempts to point out means of avoiding errors and of attaining greater precision. For that reason I submit a few unofficial observations of leveling instruments.

Several of the engineering parties engaged in the preliminary location of the new railroad now being constructed by the Federal Government in Alaska were provided with levels of the "precision" type, i.e. equipped with a mirror that permits observation of the level bubble from the telescope eyepiece, and with a vertical adjusting screw for precise setting just before reading the rod.

The value of this arrangement was conspicuously evident in attempting to run accurate levels over the many muskegs and quaking bogs encountered in that work, where the only available spots for setting up an instrument afforded such insecure support that the movement of the observer's body from the bubble to the eyepiece of an ordinary wye-level caused the instrument to be thrown out of true level.

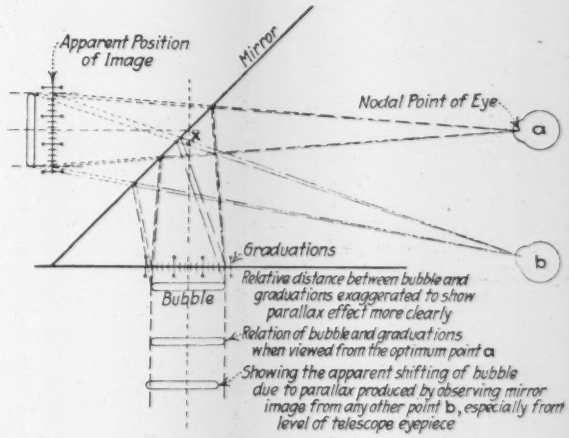

Apparent Position of Image
Mirror
Nodal Point of Eye
a
b
Graduations
Bubble
Relative distance between bubble and graduations exaggerated to show parallax effect more clearly
Relation of bubble and graduations when viewed from the optimum point a
Showing the apparent shifting of bubble due to parallax produced by observing mirror image from any other point b, especially from level of telescope eyepiece

FIG. 1. DIAGRAM SHOWING POSSIBILITY OF ERRORS DUE TO PARALLAX

In fact, the potential merits and faults of any instrument may never be fully revealed until it is subjected to a test demanding the preservation of its precision, strength and facility of manipulation under unusually rigorous conditions of climate, topography and transportation. It was possible to obtain opinions from quite a number of the men who were actually using these instruments on the work in the North. Without exception they agreed in their expressions of high praise for the level as compared with the ordinary railroad levels they had used before.

There were two faults, however, that eventually showed up—their elimination will greatly increase the value of the instruments. In two cases the bottom leveling plate, which screws to the top of the tripod head, broke off at the base of the collar that holds the joint. Rough handling—possibly, but not necessarily, careless handling—revealed the weak spot under severe conditions.

*Stanford University, California.

The more important fault has been with the mirror. Some took it off altogether; others found it a source of error unless given constant attention.

We found that there was a sufficient distance between the bubble and the etched graduations on the surface of the vial to permit parallax in lining them up, of from one to three scale divisions, depending upon the position from which the observation was made. This, of course, is true for any level, as it is of a burette or mercury barometer. The mirror renders the necessity for observing the bubble from a constant point less evident.

If the eye is at *a* and the angle between the mirror and the bubble is 45°, as shown in Fig. 1, the reflected readings of the bubble will be true. If the eye is at any other point, as *b*, the effects of parallax become evident. This is clear from the diagram. If a prominent line were etched on the mirror at the point *x*, it could be lined up, when observing, with another line across the middle of the bubble, and the parallax error avoided.

As long as the mirror is in good condition, one is apt to read it from near the proper position (*a*). But there is a danger of its being sprung out of adjustment.

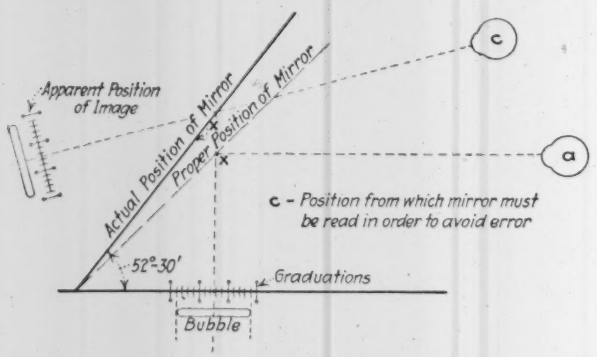


FIG. 2. DIAGRAM SHOWING POSSIBILITY OF ERRORS IN INSTRUMENT WITH MIRROR OUT OF PLACE

In order that the mirror may be folded down out of the way, it is attached by a ball-and-socket joint—the advantages of this particular type of joint have not been entirely obvious to us. The mirror is raised from its folded position until stopped by a shoulder at an angle of about 45° with the bubble. It is supposed to be held in this position by friction, but the joint soon wears so that the mirror is apt to sag, making the angle smaller.

In order to counteract that tendency the operators have learned that, before taking a reading, they must push the mirror up to the proper position against the shoulder. Now this frequent though gentle pressure is sufficient to bend or spring the mirror eventually, so that the angle it makes with the bubble is greater than 45°. On one instrument it was measured and found to be 52° 30′ (Fig. 2).

This gradual change is not readily noticed, and on finding persistent errors one is apt to overhaul every other adjustment before surmising the possibility of error from this source. It could be easily remedied by strengthening the mirror with a rib or heavier support and by using some other form of joint, as, for instance, one in which a small shoulder engages a notch, producing a "click" at the proper point. This would insure the accurate position of the mirror and yet obviate the strain produced by bringing to a sudden halt the motion of raising it.

Transfer Plate for Muck-Cars

A steel transfer plate for muck-cars in place of a switch is proving very satisfactory in the West Side water intake tunnel under construction by the City of Cleveland. Superintendent G. C. Van Duzen introduced the arrangement. The trackage in the tunnel is generally single track, with switch turnouts at occasional passing points. Approaching the heading there is a double-track section which at its shortest—that is, when just shifted ahead—is long enough to take a string of empties sufficient for mucking the excavation for one lining-ring advance (18 in.) for half the height of the face.

Back of the shield, under the lining-erector gantry, is a single track accurately aligned with one of the two tracks of the double track. Between the rear end of this single track and the forward end of the double-track siding is a space about 10 ft. long, which has no rails, but is floored with a steel plate. The plate is set at the right height to take the wheel flanges as a car is rolled on from the track, and to deliver the car to the track opposite.

A car is loaded on the single track under the erector gantry. When full, it is pushed back and rolls across the plate, taking the aligning track without assistance. The adjoining track holds the empties, and the forward one is quickly pushed ahead onto the plate, slewed diagonally and rolled over to the loading track, then pushed to loading position. The whole interchange takes only a very few seconds, the interruption in the mucking being hardly noticeable.

Mississippi River Plays with Pipe-Laying Job

By George H. Herrold*

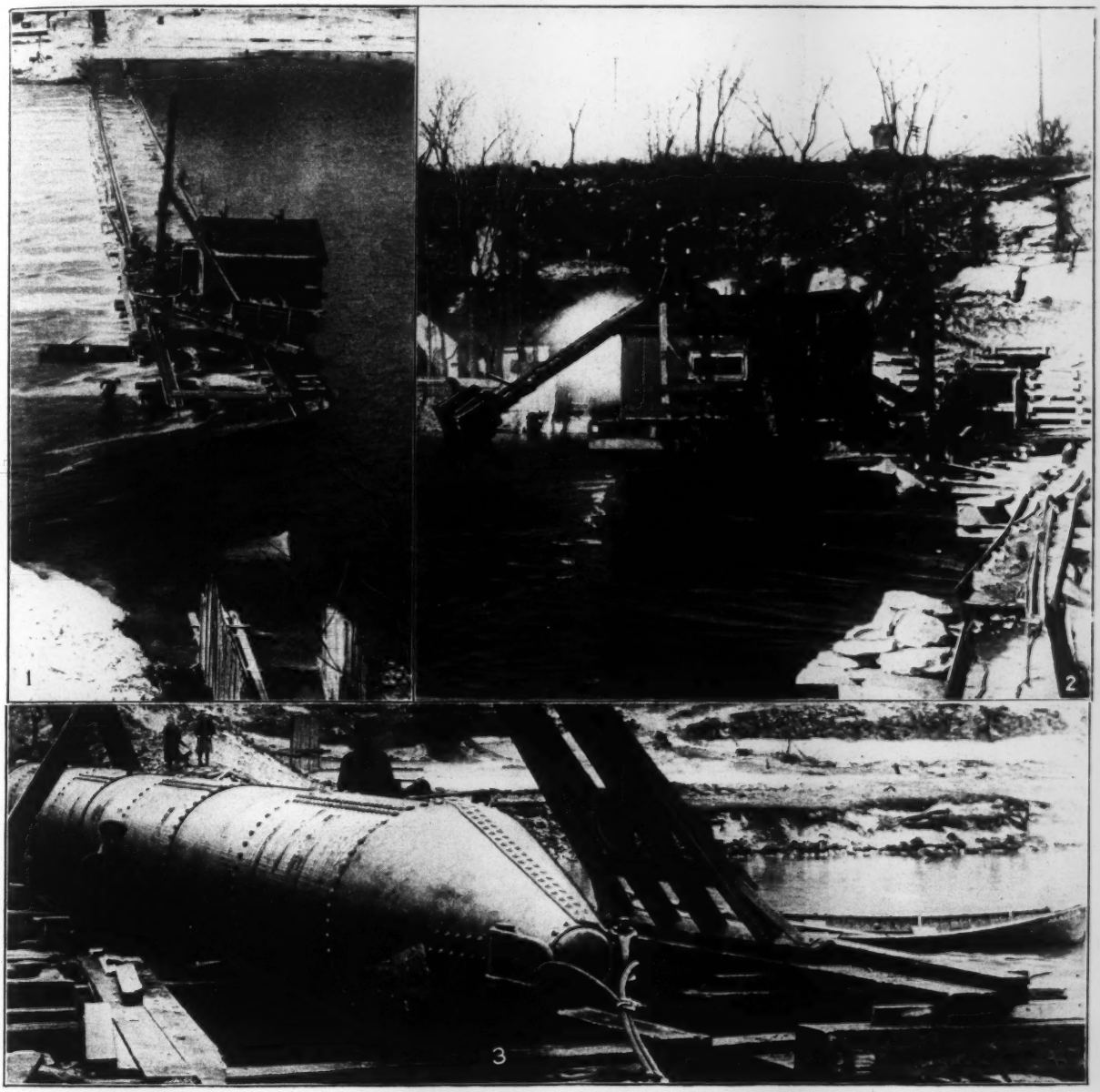
Some of the pranks the Mississippi River can play with a pipe-laying job have been shown with emphasis since a start was made to lay a 48-in. riveted steel pipe in a trench across the river at Minneapolis last spring.

The crossing is located about a thousand feet below the lower tailrace of St. Anthony Falls.[1] The river bed at this point is filled with broken limestone to a known depth of some 40 ft., this stone having been deposited in the gorge as the falls broke it down and receded.

The trench was started as planned, using a clamshell dredge, but the broken rock proved too large for it to handle, and the excavator shown in Fig. 1 was substituted. A crib bridge was built across the river to operate the machine on. These cribs were 8 ft. long, made of 10x12-in. timbers, with bottoms, each holding about two tons of stone. They were built and filled behind the excavator, then lifted by the boom and swung around and landed in position in the river bottom ahead of the excavator. I-beams were laid to form a track on which the excavator moved. Another crib was then built and placed, and so on until the river crossing was completed, Feb. 16, 1916 (See Fig. 1). The excavator then began digging the trench approximately 6 ft. deep, the center line of the river crossing being the center line of the trench. The track and cribs were removed as the excavator moved back, and the trench was completed, section

*City Engineer's Office, St. Paul, Minn.

[1]See "Engineering News," Feb. 10, 1916, p. 291, for a description of the project, and Apr. 20, 1916, p. 759, for a description of the shafts sunk on either side of the river for this crossing.



FIGS. 1 TO 3. DIGGING TRENCH AND LAYING MAIN ACROSS MISSISSIPPI AT MINNEAPOLIS

Fig. 1—Track for excavator to work on. Fig. 2—Excavator in operation. Fig. 3—Ready to haul first section of pipe out into the river trench

by section, the rock being thrown on a spoil bank on the downstream side. Fig. 2, a photograph taken Mar. 17, shows the excavator in operation at the finished end of the trench, the I-beams in the foreground forming a footpath on the spoil bank. The material excavated was in every conceivable shape and size. In many cases large irregular-shaped pieces of limestone were simply dragged and nosed out by the inverted shovel from their position in the trench onto the spoil bank.

Fig. 3, a view taken Mar. 24, shows the beginning of operations for laying the 48-in. pipe in the trench. Just at this time the ice broke in the upper Mississippi River, and an ice gorge that had formed above St. Anthony Falls broke, allowing a great flood of water to go over the falls. This rush of water carried the pipe and all the laying appurtenances up on the shore. The crest of the flood was at such height that it simply picked the pipe up and laid it horizontally along the shore line without damage. This flood condition continued several days. Then, on Apr. 6, ten million ft. of logs broke away from the Anoka boom, came over the falls and carried away every vestige of the stone spoil bank. As high water continued until July, no further attempt was made to clear the trench or lay the main.

At the present time a low-water stage exists and the trench, which was filled with sand, is being cleaned out with a drag-line excavator operated from a cable stretched across the river. The main will be laid during the extreme low-water stage of the winter. J. Arthur Jensen is supervisor of water-works, and F. W. Cappelin is city engineer.

Wrecking Heavy Machinery by Cutting Torches

The removal of the old Harrison St. power plant of the Commonwealth Edison Co., at Chicago, was necessary in connection with the construction of the new Union Station. The plant was large and included very heavy machinery, but as this equipment was of obsolete type it was not considered worth the cost of removal to another station. The entire machinery equipment was sold therefore at its scrap value to a dealer in scrap iron.

In view of the size and weight of the parts (many of which weighed from 35 to 50 tons each) the necessity of prompt removal and of doing the work at low cost made a problem for the purchaser. The method adopted was to use oxyacetylene torches to cut up the machinery in place,

FIG. 1. WRECKING STEEL SMOKESTACKS 12x125 FT. AT THE HARRISON ST. PLANT, CHICAGO

reducing it to sizes that could be handled conveniently. The purchaser contracted with expert operators to do this cutting, and five complete outfits of gas tanks, torches and other apparatus were employed in the work. These oxyacetylene outfits were made by the Imperial Brass Co., of Chicago.

Six steel smoke-stacks 12 ft. in diameter were supported by the steel frame of the building and were 125 ft. high above the roof. These were cut at the base (just above the roof) and thrown over bodily. The fall was started by jacking under one side, this being done in such a way that the stacks fell in a predetermined position. They were then cut into lengths. Fig. 1 shows one of the stacks falling. It will be seen that it had vertical stiffeners, with gusset-plate connections to the supports. The time for cutting and overthrowing each stack was less than two hours.

FIG. 2. CUTTING UP WATER-TUBE BOILERS FOR SCRAP

There were 24 water-tube boilers, averaging about 500 hp. each. The headers were cut apart, as shown in Fig. 2, and these were then forced outward by jacks, falling into the pit and leaving the nest of tubes behind. The man at the right is standing on one of the header sections, and above him is the group of tubes. To remove the huge steel coal bins above the boiler room, men went inside and cut loose the hopper bottoms, letting them fall to the

FIG. 3. CUTTING AWAY THE COAL HOPPERS OVER THE BOILER ROOM

floor below, as shown in Fig. 3. There they were cut up into pieces of size suitable for removal.

The big engines were wrecked in the same way. The 35-ft. built-up flywheels were easily handled. The dumbbell-shaped locks or clamps in the rims were cut away, allowing the segments of the wheel to be taken apart. The 36-in. shafts were tough propositions. Each was cut into

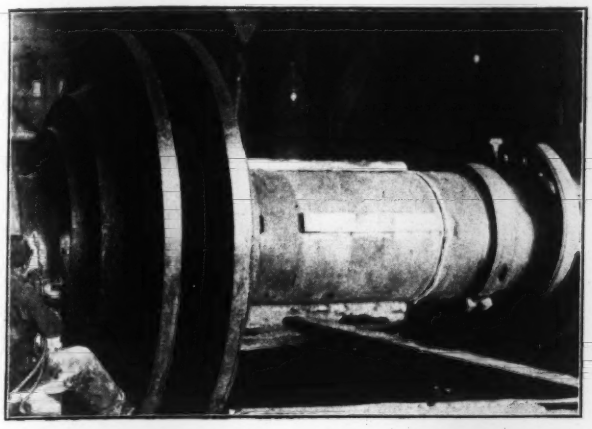


FIG. 4. CUTTING UP 36-IN. ENGINE SHAFTS (TWO CUTS PER DAY)

three lengths, and Fig. 4 shows the work upon one of these great shafts. At the right is a cut nearly completed, leaving just enough metal to carry the weight, while the operator is making the second cut (at the left), just outside the heavy flanges for the hub of the flywheel. The work was done during the summer and fall and occupied less than three months.

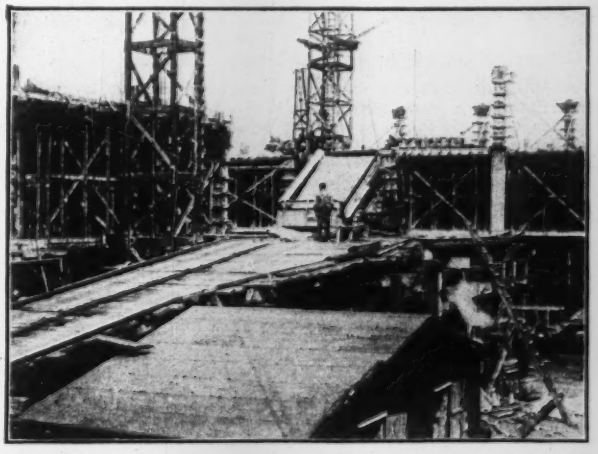
FINE AGGREGATE

New Precise Leveling Record—John H. Peters, in charge of a precise leveling party of the United States Coast and Geodetic Survey operating in Michigan between Mackinac and Jackson, made a progress of 159.6 mi. during September, 1916. The number of miles actually run was 340. The leveling is divided into sections of approximately 1 mi. each, and each section is leveled over twice—once in the forward and once in the backward direction. If the results of the two runnings do not agree very closely, then extra runnings are made until the differences in elevation between the ends of the section are nearly the same by each of two runnings. The criterion used is that the two lines shall agree within 4 mm. into the square root of the distance in kilometers. If the section is a kilometer in length, then the acceptable difference will be 4 mm. If the section is 4 km., then the allowable difference will be 8 mm., etc. As a matter of fact, the average discrepancy between the two runnings of a section is only about half the allowable limit. Mr. Peters had to rerun only about 6% of his lines, on account of failure to keep within the prescribed limits. That this record was not the result of excessive hours in the field is shown by the fact that the average time per day between the first reading and the last one was eight hours and one minute. It is not known exactly how much time was taken for noon, but Mr. Peters reported that it was probably a little over an hour. It is safe to say that the average observing period for a day was not more than seven hours. Like the other observers, during the present year, Mr. Peters is using the tripod and instrument mounted on one of the motor cars; and the adding machine, on which the rod readings are recorded, is mounted on the second motor car used by the leveling party. These two innovations (due to suggestions made by Mr. Peters) were described in "Engineering News," July 13, 1916, p. 74. —William Bowie, chief of the Division of Geodesy, United States Coast and Geodetic Survey, Washington, D. C.

Subway Costing $10,843,586.18 per Mile—New York's dual system of rapid-transit lines has the distinction of including the most expensive railroad in the world. This is the so-called Centre St. Loop, the cost of which to the city to June 30, 1915, as figured by Chief Engineer Craven, of the Public Service Commission, was $16,080,964.09. This is at the rate of $10,843,536.13 per mile of subway, and $3,050,837.43 per mile of track. The amount does not include the lessee's contribution toward the cost, or its expense for equipment, or additional payments for interest yet to be charged by the city. When these are added, the aggregate cost is likely to be nearly $2,000,000 more. Of the $16,080,964.09, however (the total cost to June 30, 1915), only $11,846,145.67 was for labor and materials. The remaining $4,234,818.42 was for salaries and expenses of the Public Service Commission's employees, and for interest. This scant mile and a half of subway contributes practically no new additional revenue to the system. The interest on its cost and the expense of its operation must be met almost entirely by the other rapid-transit lines operated by the New York Consolidated Railroad Co. This is one of the misconceived transit luxuries which that company is obliged to carry under its contracts with the city, and is one of the factors which make the company's burden severe.—"B. R. T. Monthly."

Tractor and Plows Dig Out Gravel Layer—When excavating for the construction of a wood-block teamway, in the Illinois Central Main St. yards, Evansville, Ind., 18 in. of conglomerate gravel (known as Paducah gravel in the lower Ohio region) was found under 6 in. of broken stone. The contractor made several unsuccessful attempts to start a rooting plow with three teams, but it was impossible to break the gravel. The plow was finally attached to a steam tractor and the gravel loosened. Several plows and chains were broken during the work. It required four days with the tractor on 1,500 sq.yd. of surface. The necessity of using the steam tractor in a small space and the difficulty of loosening the gravel so that it could be shoveled on flat-cars cost the contractor almost double the original estimate, which had been made without a thorough examination of the locality.—E. W. Bullard, Building Inspector, Mechanicsburg, Ill.

Motor Trucks Dump at the Second-Floor Level of the $500,000 building now being erected in Cleveland for Richman Brothers. The Cleveland Builders' Supply Co., which has the contract, has erected a wood platform at the level of the second story and has connected platform with ground by two

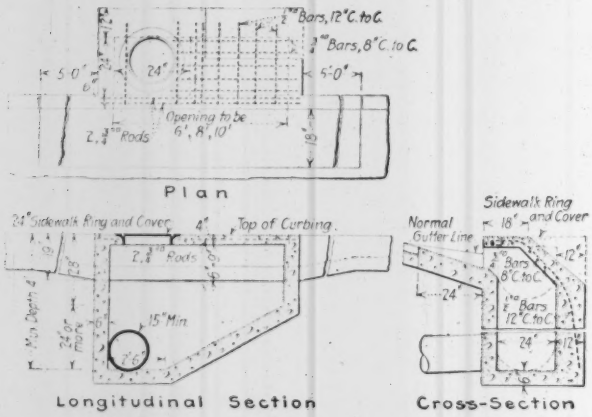


TRUNKS DUMP AT SECOND FLOOR LEVEL OF NEW BUILDING, CLEVELAND

plank inclines having a grade of about 10%. Concrete materials are delivered on the platform by a fleet of nine White power-dumping trucks. Having two inclines keeps the trucks running continuously.

Economizing Compressed Air—A useful little expedient was adopted in the Milwaukee water intake shore tunnel by the O'Brien & Jackson Co., contractors. The tunnel is being driven under compressed air and in addition air chisels are used in some of the headings for excavating in hardpan and hard clay. The intermittent operation of the tools is apt to produce considerable waste of power in blowoff from the receiver. To avoid this waste, a blowoff valve set at 90 lb. was placed on the high-pressure air line within the tunnel, on the heading side of the air lock. Whenever the demand of the air chisels is low the excess high-pressure air escapes into the tunnel via this valve, and thus increases the low-pressure air supply and reduces the load on the low-pressure compressors.

Reinforced-Concrete Curb Inlet—The accompanying figure gives the details of a reinforced-concrete curb inlet and catchbasin used as a standard in San Antonio, Tex. It is essentially a narrow rectangular box, with 6-, 8- or 10-ft. opening in the curb. At the manhole opening the width of the



DETAILS OF CONCRETE CURB INLET, SAN ANTONIO, TEX.

box is 3 ft., but at the other end only half that amount. Only the top and the overhanging part of the side of the box are reinforced. The bottom is rounded to an arc of a circle and is sloped as shown in the longitudinal section. The sewer engineer of San Antonio is M. E. Erwin.

Well-Hole Quarry Blasting—The following changes were recommended by S. R. Russell in a recent issue of the "Du Pont Magazine": In hard rocks a combination of 60 and 40% dynamite is advisable; a little 60% should be loaded in the bottom of each hole and 40% used on top. In softer flat limestones a 40% explosive will usually be found strong enough and often a lower grade can be used for top load. If the work is very wet and the toe heavy it may be necessary to use a gelatin dynamite from 40 to 60% strength. Sand, clay or fine screenings should be used for tamping and holes filled up to the collar. In holes up to 35 ft. deep a tamping pole or stick can be used handily. If of greater depth it is necessary to use a rope and block as a tamper.

A Monthly Postcard Picture, showing some work under construction by Bent Bros., engineering contractors of Los Angeles, Calif., is sent out by that firm for publicity purposes. The August postcard is shown herewith. The view is of a power backfiller, used to trim the inner slope of a large circular earth reservoir recently completed for the Standard Oil Co. at El Segundo, Calif. The reservoir is 403 ft. in diame-

CONTRACTOR'S POSTCARD ADVERTISEMENT

ter at the bottom and 19 ft. 2 in. deep, having a 1½ to 1 slope. After the slope was trimmed and thoroughly rolled, a 3-in. concrete lining was placed. In the space for writing, on the reverse side, under a heading "Contracts in Progress," is a list of contracts now under way by Bent Bros.

Interest Rate in Loan Repayment—Virgil A. Eberly, of 272 Pennsylvania Ave., Washington, D. C., has solved the problem in interest rate on a loan repaid by installments, as given in "Engineering News," of Nov. 2, 1916, p. 852. If the total debt is A and the number of equal annual payments extinguishing it is n, and if the interest percentage is 100 ÷ b, then the general formula is

$$\text{One payment} = A\left[\frac{(b+1)n}{b(b+1)^n - b^n + 1}\right]$$

With b as the unknown, this formula must be solved by trial, but with seven-place log tables a solution can be obtained to within $1, in not over five or six trials. In the particular problem given, the fractional period at the beginning makes a little further complication. The $1,000,000 loaned today will draw interest at the rate of $\frac{100}{b}$ % for $\frac{13}{24}$ year. The debt at the end of 6½ months will therefore be $1{,}000{,}000\left(1+\frac{13}{24b}\right)$ dollars. At this time, however, $120,000 is paid, reducing the debt to $1{,}000{,}000\left(1+\frac{13}{24b}\right) - 120{,}000$ dollars, which represent A in the above formula. The statement of the problem will therefore be

$$120{,}000 = \left[1{,}000{,}000\left(1+\frac{13}{24b}\right) - 120{,}000\right]\left[\frac{(b+1)^{11}}{b(b+1)^{11} - b^{12}}\right]$$

This may be reduced to

$$12b - \frac{12b^{12}}{(b+1)^{11}} = 88 + \frac{1{,}300}{24b}$$

which by approximation gives $b = 15.05 \pm 0.01$ — (on sixth trial). By further trials a value correct to seven places should be sought; $b = 15.05$ gives the rate at $6.6445 \pm$ %.

Laying Water Main with Locomotive Crane—In the work preliminary to the West Side track depression of the Nickel Plate railway at Cleveland, Ohio, it was necessary to lay two new water mains of large size along West 41st St., passing under the present surface tracks at a depth sufficient for the

LOCOMOTIVE CRANE LAYS 36-IN. STEEL WATER MAIN IN 30-FT. SECTIONS

separation of grades soon to be started. The two mains are a 30-in. low-pressure and a 36-in. high-pressure. The railway crosses the street at nearly a right angle, and the grades are to be separated by raising the street and depressing the tracks, approximately equal amounts. Instead of taking the water mains across on the viaduct they are to pass under the depressed railway tracks. This required their being lowered 24 ft. from the present street level. The trench was dug one-half the necessary depth as an open cut with 1½ to 1 slopes. The remaining 12 ft. was excavated between rows of 2-in. wood sheet-piling. A 10-ton locomotive crane with a 1-cu.yd. Owen clam-shell bucket was used for excavating. A track was laid parallel to the trench to operate the crane. A second track, connecting with the crane track, was used for the dump-cars that removed the spoil. Below 12 ft. the trench had to be kept pumped out by an electric motor-driven centrifugal pump. The pipe is of riveted steel, in 30-ft. sections, with flanged couplings. Each section weighs nearly 10,000 lb. Each end section is bent upward at an angle of about 33°, the horizontal part being about 24 ft. long. The trench was made 10 ft. wide, and the rangers and struts were placed in such a way that it was possible to snake the pipe under them without moving a timber. This was accomplished by placing the three end struts and rangers at such an inclination that a section of pipe could be slipped under them into the bottom of the trench. The work was carried out by F. W. Claflin, field engineer, under A. J. Himes, engineer of grade-crossing elimination of the New York, Chicago & St. Louis R.R.

Editorials

Rapid Changes in Market Prices Affect Engineering Problems

The engineer engaged in design and construction, laboring at his perpetual task—to quote the famous definition—of making a dollar earn the most interest, has had his work greatly complicated during the past two years by the rapid changes in prices of engineering materials. In the past, practicing engineers have generally come to rely on standard relations that engineering practice has pretty well established as to the relative cost of structures of different types.

For example, in *Engineering News* of Nov. 9 were published statements by two prominent men in the structural field on the relative cost of factory buildings of reinforced concrete and of standard timber mill-building construction. One of these men reported the reinforced-concrete type as costing 30% more than the timber construction; the other reported the excess as only 17%.

Which of these figures is the more accurate as a general guide it is not our present purpose to discuss, but it does seem worth while to call attention to the fact that comparative figures that were accurate six months ago or even three months ago may, under present-day market conditions, be very far from accurate. At the present time, for example, the phenomenally high cost of steel, coupled with the difficulty of obtaining prompt delivery, is greatly stimulating the use of reinforced concrete instead of steel, where the two materials are in competition with each other.

In the extensive railway reconstruction work now in progress on the main line of the Southern Ry. the engineers had planned to build a steel viaduct 200 ft. high at the crossing of Broad River. On account of the high price of structural steel the plans have now been altered, and the structure will be made up of high towers of concrete, made hollow, with circular interior and rectangular exterior, spaced 120 ft. apart on centers, with 100-ft. girder spans between the towers. But concrete as an alternative for steel may even show a smaller margin of economy in the future, because it is more than probable that cement will go to record prices. It has held remarkably firm during the past year, but a reduction in the surplus stock and the tremendous increase in cost of coal and of labor point indisputably toward a marked rise in the cost of cement.

Another alternative in some lines of construction is earthwork. On the railway work mentioned before, at the crossing of another broad valley a fill is being made 1,500 ft. in length and 100 ft. in height, with a maximum width of 533 ft., instead of crossing this valley by a steel viaduct, which would be the plan adopted if steel were available at the ordinary prices.

Two very potent factors that the engineer has to consider today in making comparative estimates of costs are the low price of timber compared with most other engineering materials and the high price of capital. It appeared likely a few years ago that the standard timber-frame factory building, developed in such admirable fashion by the Mutual Fire Insurance Companies of New England, was destined to disappear and be replaced by the reinforced-concrete structure. Under present market conditions, however, the case for the timber building is more favorable than it has been for a long time. The first cost is far from being the only consideration. The engineer who is putting up timber mill buildings at the present day needs to take advantage of the latest information in order to protect such a building from the dangers of dry rot and of attacks by fire.

The effect of high prices for capital is to stimulate the use of lower-priced materials, even though the resulting structure is of shorter life. Unless a structure on which an engineer is figuring is to be erected for a state or a municipality, the engineer is seldom able at the present time to figure on an interest rate less than 5½%; and on most capital raised by either railway or industrial companies today the final cost, with brokerage charges included, is apt to be from 6 to 7%.

Engineers Who "Butted In" on a Public Question

Those who are following the debate as to whether engineers should take an active interest in public questions will find a valuable record of experience in the report elsewhere in this issue of a committee of engineers who investigated the municipal water-power enterprise on which the City of Montreal has been at work for some years. The committee shows that the $12,000,000 enterprise which the city has about half completed will fall so far short of returning a profit on its cost and has so many serious defects that it will be far better for the city to lose all it has thus far expended than to incur the additional outlay necessary to complete the work.

It appears that this work was undertaken by the city in the first place without any thorough investigation to determine beforehand whether or not the scheme would be profitable. The Canadian Society of Civil Engineers took up the matter a year ago and made strong representations to the city authorities, urging that an independent investigation of the project should be made. The society's efforts were fruitless, however, the intelligent city fathers very likely construing the appeal as merely a scheme to obtain appointments for engineers.

As the city authorities paid no attention to the representations made by the national engineering society, 31 engineers who were citizens and taxpayers of Montreal joined in urging upon the city authorities an investigation. Very likely this appeal also was construed as a scheme to obtain appointments, for it is stated that some of the aldermen suggested that if the taxpaying engineers chose to make an investigation and report free of cost to the city it might be considered. This challenge was promptly accepted. A committee to investigate was named by the association of engineer-taxpayers, and its report has just been presented. Its logic is so unanswer-

able that the city authorities will probably be obliged to abandon the work in accordance with the committee's recommendations.

It is of course easy to present arguments on the other side and to say, for example, that the failure to heed the protest of the Canadian society shows how little weight is given to the opinion of professional engineers by the average municipal official. It may be said also that the protest ought to have been made years earlier, before the city embarked on the enterprise and expended the $5,000,000 or so which now promises to be a dead loss. The eminent engineers who have made this report free of cost to the city may be criticized for having rendered a professional service for which the city ought to have paid a fair price.

One has to deal always, however, not with ideal conditions, but with practical conditions. It very often happens, unfortunately, that cities and states and even the Federal Government undertake enterprises without any proper engineering investigation in advance, and often even against the advice of experts. It is true also that many times the technical and financial questions in connection with such enterprises are so complicated and involved with so many questions of personalities, vested interests, etc., that an engineering society cannot safely undertake to express a formal opinion upon the matter.

There are, however, plenty of cases, of which this Montreal work is an example, in which the evidence is so clear as to the infringement of sound engineering principles that the engineers and the engineering societies who are most conversant with the situation may well consider it a duty to use their influence for the public benefit.

Canada and its cities cannot possibly afford just now to waste any money in unprofitable municipal enterprises. The Montreal engineers who as citizens and taxpayers have come forward to warn the city as to its dangerous extravagance have rendered a patriotic service quite as valuable to their city and to their country as if they had volunteered for military service.

The Daylight Saving Movement and Standard Time

Those who are taking part in the agitation to move forward the hands of the clock one hour during the summer months ought to clearly understand some of the difficulties that are involved in any such tampering with the present standard time. Few, probably, of those who are taking part in this agitation are old enough to recall clearly the chaos in the matter of time, which prevailed in the United States prior to 1883. The confusion and danger resulting from this condition was so great that it led the railway companies of the United States to form the first general organization to undertake coöperative action. That organization was known as the General Time Convention, and was the predecessor of the American Railway Association. Its leading spirits were two eminent engineers, the late Sir Sandford Fleming, then one of the principal officials of the Canadian Pacific Railway, and the late W. F. Allen, who later became the Secretary of the American Railway Association.

Prior to the adoption of standard time it was common to have three or four different times in use in a city. Besides the city time there would be the times used by different railways entering the city. Some of these standards would differ as much as fifteen or twenty minutes from each other. At the celebration of the 25th anniversary of the establishment of standard time on Nov. 18, 1908, Mr. Allen, in recounting the conditions that prevailed before standard time was established, said:

> There were then 53 times of various cities in use by American railways and by the people generally. It is doubtful if there were more than a dozen railway officials in this country who could have stated from memory what time was used by any road other than their own, and the few with whom they had direct business connections. So crude were some of the time standards used, that one railway superintendent reported, in response to a circular of inquiry, that the standard used by his road was the superintendent's watch.

The committee on standard time of the American Railway Association, reporting on the daylight saving movement this week, declares that the present zone system of dividing time is absolutely correct. Any change in it would result in endless confusion and would be disastrous to the railways. The committee recognizes that if by *nation-wide* action the hands of the clock could be set forward one hour on a certain day, the change would be practicable, but it believes that the change is not warranted from the scientific standpoint.

If, however, the result of the daylight saving agitation should be to cause a number of different cities in various parts of the country, following the bad example of Cleveland, to establish a local time different from the railway time, a long step would be made toward reëstablishing the confusion in time standards that prevailed in the United States prior to 1883.

The ends sought by the promoters of the "daylight saving movement" are commendable enough; but it is yet to be proved that in order to bring about a readjustment of the working hours of factory employees, it is necessary to tamper with accepted standards of time.

No Bidders for City Contracts

At a recent meeting of the Board of Public Works of Indianapolis to open bids for various municipal work, it was found that on five contracts that had been publicly advertised for letting, no bids whatever had been received. On two other contracts there was only a single bid, and on three other contracts there were only two bids in each case. These figures undoubtedly reflect accurately the labor scarcity prevailing through a large part of the Middle West and to a greater or less extent in other parts of the country. Contractors doing public work have in many cases found it difficult to secure the labor necessary to carry out their contracts already in hand. Under these conditions they are not at all disposed to submit bids on additional contracts on the chance that conditions may change so that they will be able to secure the necessary labor.

There is no doubt whatever, looking at the question from a broad standpoint, that it is wise public policy at the present time to cut down expenditures for municipal improvements to the lowest point possible. Most materials for construction are at the highest prices known since the Civil War. Labor is not only high priced, but, owing to the necessity of taking anything and everything, with the fact that the men realize if they lose their job another one is waiting for them around the corner, the amount of work done is comparatively small.

Nothing can be more certain than that this condition must change, sooner or later, and the change when it does

come will probably be rapid and extreme. Less than two years ago city councils all over the country were wrestling with the pressing problem of finding work for the unemployed. This problem will again recur and very likely at no distant day. All the public work that can be postponed from the present time to be undertaken then will serve to relieve the present market stringency, will give the workingmen something far better than charity when the pinch comes and will make the taxpayer's dollar yield a far greater return in the work accomplished than will be the case if it is spent now.

On the other hand, there is a very large amount of public work that does not admit of postponement. The present era of prosperity has brought a great influx of population to dozens and hundreds of cities and towns. It has become necessary not only to build houses to shelter these additional city dwellers, but the streets where these houses are built must be furnished with paving, sewerage and lighting.

The public is demanding that money be spent on road construction and maintenance now. In maintenance especially, much work must be done to prevent the loss of large investments in road improvement already made. A large proportion of municipal work is carried on by assessments on the property holders. It is much easier to carry on such work on a large scale in prosperous times than it is at times of business stringency when the city authorities are deluged with appeals not to impose assessments on those who are unable to pay.

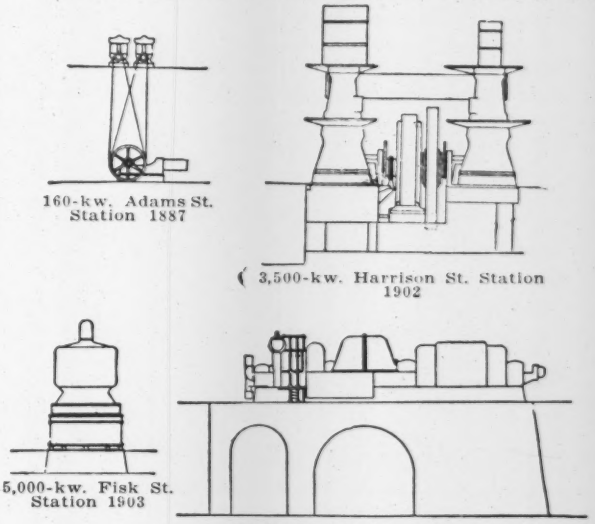
All these conditions point to continued activity in municipal and other public work, notwithstanding the high prices and scarcity of both materials and labor.

Rapid Changes in the Electric Lighting Industry

The article printed on page 1040 of this issue, describing the methods used in cutting up for scrap the huge steam engines, water tube boilers, and other equipment of the Harrison St. power plant of the Commonwealth Edison Co. at Chicago, may cause some readers to ask the question why this machinery, much of it in good condition, was not worth saving? As stated in the article, one reason for its being scrapped was the heavy cost that would be involved in its removal and reërection on another site, but the more important and really controlling reason was that the machinery had become obsolete.

A notable address by Samuel Insull, President of the Commonwealth Edison Co., before the American Society of Mechanical Engineers, which is printed in that Society's "Journal" for November, reviews the rapid changes which have taken place in the electric central station industry. The accompanying cut, reproduced from Mr. Insull's paper, shows the relative size of the power generating units used by the Commonwealth Edison Co. at four different periods in its history. As shown in that cut, the power equipment in the Harrison St. station was the huge reciprocating engines direct-connected to slow-speed generators which only fourteen years ago were considered a marvelous achievement in power development, and rightly so considered when one compared them with the little steam engines belted to dynamos with which the electric lighting industry began. A special feature of Mr. Insull's paper is his emphasis on the "lag" in the mental attitude of engineers and others toward improvments in practice. Mr. Insull said:

> One of the most up to date steam railroad systems in the United States today is probably the New York Central line I think they have two stations equipped with precisely the same kind of apparatus as that which we discarded several years ago.
>
> There came out to Chicago some years ago a very distinguished engineering commission for the purpose of gathering information to be used in designing a large plant. The commission decided to duplicate what we had and for fear they would not be able to run it they purloined one of our men to run it and are still running it. What they copied has been in the scrap heap for years.


160-kw. Adams St. Station 1887
3,500-kw. Harrison St. Station 1902
5,000-kw. Fisk St. Station 1903
35,000-kw. Northwest Station 1915

FOUR TYPES OF GENERATING MACHINERY USED BY THE COMMONWEALTH EDISON CO. OF CHICAGO

By way of illustration of the great advantage the large size turbine generator has over the reciprocating engine of about one-tenth its capacity, Mr. Insull stated that their standard 30,000-kw. turbo-generators with horizontal shafts are run at 1,500 r.p.m. giving the revolving field a peripheral speed of 20,000 ft. per min. It is the practice to run a machine of that type practically all the time. The best results and the lowest repair costs are obtained if such a machine runs continuously, provided it is shut down a few hours a week for inspection to see that everything is in order. The contrast between such a machine and the older type of machinery which required frequent stops and overhauling to keep it in adjustment, provide for lubrication, etc., can be readily appreciated.

Selling Good City Government the City Manager's Job

Since Galveston led the way after the great flood of 1901, perhaps 500 cities of the United States have adopted the commission plan of city government. By and large, the change has brought a great gain over results under the older forms, but it has generally left much to be desired in the way of further improvement. In so far as this deficiency is not due to the unreadiness of the people for good city government it may be explained largely by an inherent weakness in the commission plan. This weakness, often mentioned in these columns, is the attempt to select the heads of executive departments by popular vote and then to run a city with five coördinate executives and no one official in supreme command.

It is a significant fact that only two or three of the 500 commission-plan cities have gone back to their antecedent types. Instead, many of the commission-plan cities and a considerable number of cities and towns under the older plans, have made a more or less clear separation of legislative and executive functions by the employment of a single executive head, called the city manager.

Save for a very few isolated pioneer cases the adoption of the city-manager plan has taken place during the last three or four years. Today nearly a hundred cities have city managers or have taken steps to secure them. Such rapid progress is gratifying, but the fact still remains that the body politic of most cities is not ready for as good city government as might easily be got with its party support out of the particular form in vogue, be it mayor and council, commission or commission-manager.

The city managers seem to have a clearer vision of the current indifference if not opposition to good city government and of the way to overcome it than have any other class of city officials. The case was put in new form and strength by H. M. Waite, retiring president of the City Manager's Association, at Springfield, Mass., last week.

We are selling good government to the public. It must be wrapped in attractive packages and offered with civility and patience. Some of the things have to be sold first to a few chosen easily interested citizens, then to some not so much interested and to the newspapers. Public confidence must be obtained and never abused.

The city managers are right. They must sell good government to the public. But this is not enough. The public should demand good government from the managers. Otherwise the fundamental principle of the city-manager plan falls to the ground. That principle is that the commission or council is elected by the people to frame policies and that the function of the manager is to execute the policies determined by the commission. Until the people realize and act upon this principle the city managers must not only work against great odds to produce good city government but must also devote a large part of their time and energy to selling it to a more or less reluctant public.

More Success in Converting Hindsight to Foresight

The full description and frank discussion of a canal-lining failure in Massachusetts, printed elsewhere in this issue, as willingly contributed by the engineers most closely concerned in the work, is another of the accumulating evidences of a truer realization of the real benefits of recording failures for the instruction of other members of the profession. Here the record of early failure and final success in securing, at low cost, stability of steep slopes makes a noteworthy professional contribution. It actually turns these men's hindsight into others' foresight—and that is the prime object in giving as much space as we do to various accounts of failures.

Hardly an issue of this journal appears that does not give the details of some such accident—now it is a fallen bridge span, again it is a washed-out dam or a collapsed building. All such matters are carefully investigated, that their lessons may be fully comprehended and not that blame may be fixed or that any morbid delight in post mortems may be satisfied. We believe it is obvious that as much advance comes out of engineering failures as from apparent successes.

Naturally we are gratified by the acceptance of this principle by the men who have to face these trying circumstances. The repetition of such cases in recent months seems to present growing evidence of a better spirit among engineers—more of an *esprit de corps* which uplifters have nearly despaired of securing. Where we have failed to find such openmindedness, it has sprung usually from the instructions of some legal counsel, naturally secretive and suspicious.

Letters to the Editor

Five Essentials of Effective Business Letters

Sir—It may interest your readers to hear of a new grouping of the rules governing the composition of effective business letters. As far as I know at the present time, the following grouping, simplified to assist the memory, is a new one. This grouping is known as the five C's of business correspondence. The five C's are: Clearness, Accuracy, Conciseness, Courtesy and Conviction.

The order is not accidental. Clearness is the first requisite of good composition; it is achieved by means of accuracy and conciseness. Conviction is the ultimate aim of the business letter. A letter cannot, however, be convincing if only clearness, accuracy and conciseness have been achieved. Courtesy is the leaven without which the first three C's would never rise to conviction.

ADOLPH C. BAEBENROTH,
Professor of English, Syracuse University.

Syracuse, N. Y., Nov. 16, 1916.

Plotting the Catenary

Sir—Frederick R. Honey, in *Engineering News* of Aug. 10, has indicated a method of plotting and rectifying the catenary that involves much needless labor.

Taking the parameter c as the unit of measurement, with the origin at the vertex, the equation of the curve becomes

$$y = \cosh x - 1$$

and the length of arc from vertex to point (x, y) is $\sinh x$. The essential data may therefore be obtained directly from a table of hyperbolic functions, and the laborious approximation for the length of the curve by means of small circular arcs is, of course, unnecessary.

There are other well-known and simple methods of plotting and rectification that necessitate neither the use of hyperbolic tables nor the evaluation of the expotential.

R. C. STRACHAN.

Municipal Building,
New York City, Aug. 11, 1916.

Water Filters and Typhoid at St. Louis, Mo.

Sir—Enthusiasm over the new filter plant in St. Louis has led the officials in charge of the plant, in their annual report just received, to ascribe to the plant credit that the tables and the diagrams contained in the report flatly contradict.

The writer is of the opinion that modifications and improvements could have been made in the clarification process which would have substantially bettered the output of the plant at a fraction of the cost of the new filters. Filters, however, were considered essential, and it goes without saying that the statement of the results obtained therefrom should be accurate. The report says:

The decrease in death rates in 1905 as compared to 1903 and 1904 was no doubt largely due to the installation of the clarification process, while the decrease occurring in 1915 followed the filtration of the entire water-supply, which began in May, 1915.

According to the tables in the report the sharp break in the typhoid death rate began in December, 1914, or six months before the filter plant was put in operation, and the percentage reduction in the death rate for the six months preceding the operation of the filters is greater than that for the six months following the introduction of filtered water; but even if the opposite condition prevailed, no such sweeping statements should be made based upon a six months' period of operation.

While the filters will undoubtedly give a more highly polished water than was obtainable from the excellent clarification method employed for 11 years, the writer questions that any marked decrease in death rate will result from the introduction of filters. Consequently, the incorrect statement in the paragraph above quoted and the error in the diagrams themselves, which show that the date of the introduction of the filtered water was coincident with the sharp reduction in death rate in 1915, should be pointed out. ALEXANDER POTTER.

50 Church St., New York City, Nov. 18, 1916.

Chemicals for Weed Killing

Sir—In your issue of May 25, 1916, p. 1000, we note your article headed "The Cost of Track Weeding," as compiled by Edward Karow, Assistant to the Vice-President of the Twin City Rapid Transit Co. We aided Mr. Karow in getting at some of the figures given under the heading "Chemical Weeding," and from our experience we believe the average figures under all headings to be approximately correct.

We disagree with the comment, that manual labor weeding leaves the track in the cleanest condition. It must be remembered that hand weeding in no way permanently kills the vegetation and, therefore, regrowth will start within a very few days, while, on the other hand, chemical weeding leaves the track comparatively clean for the entire season. It is also the object of chemical weeding to repeat the second year and following years' treatments sufficiently early to prevent regrowth establishing itself in that season.

Hand weeding gives a clean track for possibly ten days to a month after the work is accomplished, but never averages clean track during an entire season.

R. M. CHIPMAN,
General Manager, Atlas Preservative Co.

New York, Nov. 16, 1916.

Salt Water Causes Cracking Concrete in Philippines

The cracking of reinforced-concrete structures is markedly prevalent in the Philippine Islands, according to a report by J. L. Harrison, District Engineer, Iloilo (in the "Bulletin" of the Bureau of Public Works, October, 1916). The accumulation of evidence of this trouble became so serious about two years ago that it was decided by the authorities to make some studies into the cause. They proceeded first on the assumption that the rusting was wholly chemical—stimulated by appreciable quantities of some determinable material; and a number of samples of concrete taken from structures in trouble were subjected to chemical analysis.

The samples submitted showed one foreign substance—chlorine—and that indicated the presence of salt. At first not much attention was paid to this, as it was known that it was largely used in the United States to prevent freezing of concrete during setting; but it was soon realized that the climatic conditions in the Philippine Islands are so different from those in the United States that the effect of the salt could not be neglected. The collection of analyzed samples has gone on for something over two years and not a single structure showing rusted steel has been found free from salt. The percentage of this salt has varied considerably—from that high enough to show that beach sand and sea water must have been used in making the concrete, to a figure low enough to indicate that either brackish water was used or that salt water was used to wet down fresh-water concrete after the forms had been taken off. A typical sample (from the Constabulary Headquarters building, Iloilo) showed 0.07% chlorine. This was computed to be equivalent to 1.44% salt in the water, assuming 12.5 lb. of water used per cubic foot of concrete. This is considered fairly salt water.

The presence of 0.10% chlorine in the iron rust indicated too small a percentage of ferric chloride to explain all the indications of rusting to be observed; but it was realized that ferric chloride is not stable and that it readily oxidizes to ferric oxide, releasing the chlorine for further attack. High temperature and moisture are the only conditions necessary for the indefinite continuation of the process, and both of these conditions prevail throughout the Philippine Islands.

Not every structure in which salt water has been used, or in which salt is found, goes to pieces in this way. There are several such buildings in good condition. However, the concrete in them is unusually dense, and it is thought that their success in withstanding the influence of the salt is due to the density of the concrete.

Engineers in the Philippines have been accordingly advised that all use of salt water in concrete structures is dangerous and that the use of beach sand and beach gravel should be permitted only after thorough washing with fresh water.

The Volume of Coal Traffic at four principal Atlantic seaports has been investigated by the United States Geological Survey. The figures are approximate only and give the totals in net tons for the year 1915. New York leads with 27,000,000 tons; Hampton Roads comes next with about 16,000,000 tons; then Philadelphia with something over 13,000,000 tons, these figures not including the bituminous coal consumed in Philadelphia itself. The total receipts at Baltimore were about 7,600,000 tons.

Engineers Condemn Montreal's Municipal Power Plant

SYNOPSIS—Voluntary commission of local engineers reports that Montreal's proposed municipal water-power project is ill advised.

One of the most frequent sources of large loss in the works carried on by the Government—Federal, state or municipal—is the undertaking of enterprises without sufficient preliminary information to determine whether they are worth while. A remarkable example of this has just been brought to light at Montreal through the work of a voluntary commission of engineers, organized under unusual circumstances.

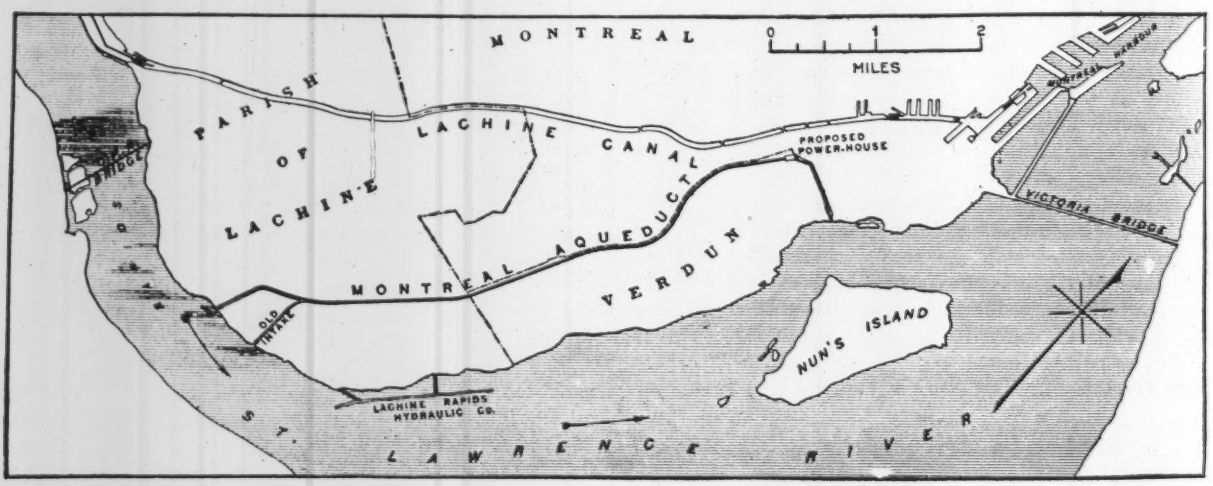
As briefly summarized in the last issue of *Engineering News*, this commission of engineers finds that the city has about half completed a water-power project that will cost when finished at least $11,000,000, but which is so expensive and so unreliable that the city had better lose all the money it has already spent rather than carry the project farther.

The story is such an excellent illustration of the way in which taxpayers' money is frequently wasted through the failure of public authorities to employ competent engineering advice that we present herewith the following particulars from the commission's report:

About the middle of the last century the City of Montreal secured a new water-supply from the St. Lawrence River, taking water from the river near the head of the Lachine Rapids, carrying it in an open canal about five miles toward Montreal and discharging back into the river such part of the flow as was not required for city consumption. The power developed by this surplus water discharged back into the river at the lower end of the canal was used for pumping the city supply.

As every engineer familiar with water-power developments in northern latitudes is aware, ice troubles in winter from frazil or floating ice are very frequent. Much trouble was experienced at the city pumping plant, so that steam power was gradually substituted for water power. In 1905, Georges Janin, who was then superintendent of the water-works, recommended to the city authorities that in order to save the cost of pumping by steam the canal should be enlarged sufficiently to produce water power amounting to 5,000 hp. in summer and 2,000 hp. in winter, in addition, of course, to the amount of water required for municipal purposes. It was computed that the saving over steam power would be sufficient to pay a large return on the cost of enlarging the canal and other expenses made necessary in connection with it.

In order to enlarge the canal, however, it was necessary to provide a water-supply for the city while the enlargement was going on, and a closed reinforced-concrete conduit was constructed alongside the canal. This closed conduit was completed in 1909, and work on the enlargement of the open canal then commenced. While this work of enlargement was going on, Mr. Janin recommended that the size of the canal be further increased so that the water discharged by it would be capable of developing 10,000 hp. This recommendation was also accepted, and part of the work was put under contract in July, 1913.



MAP SHOWING LOCATION OF AQUEDUCT FOR WATER-SUPPLY AND POWER DEVELOPMENT AT MONTREAL

The city authorities appear to have decided upon carrying out this enterprise solely upon the recommendation of Mr. Janin. No engineer or body of engineers was engaged by the city to investigate and report upon the merits of the enterprise, and even Mr. Janin himself appears never to have thoroughly investigated the whole enterprise. Although the work is now half finished, no complete plans and estimates have ever been made of such essential parts of the project as the river intake, the power house or the necessary outlet works in the river below the tailrace.

Public attention was called forcibly to what was going on on Dec. 25, 1913, by the breakage of the reinforced-concrete conduit supplying the city with water. Investigations made by a board of engineers, called in by the

city authorities, showed that the excavations carried on in enlarging the canal were seriously endangering the concrete conduit alongside. The City of Montreal was put in perilous condition by the cutting off of its water-supply, and the emergency would have been even more serious, except that a large part of the city is supplied with water by a private company.

About this time criticism of the project as a whole appeared in the public press, and it was pointed out that the saving promised by the construction of the power plant was not at all likely to be realized. The city authorities, however, made no move in the matter, and the engineers who were called in to investigate the break in the conduit, while they recommended to the city that the whole project should be carefully studied, had no authority to make such an investigation.

As no action had been taken on the report of these engineers, the Canadian Society of Civil Engineers, in July, 1915, urged the city authorities to order a full investigation of the project. This recommendation was ignored, and in October the society renewed its appeal. Its criticism was further emphasized by a comprehensive article in the *Canadian Engineer*.

As the city authorities ignored these criticisms and recommendations, 31 engineers who were citizens and taxpayers of Montreal signed a protest to the city authorities in April, 1916, urging that an engineering commission be appointed to investigate the project. Later, a delegation of these engineers appeared before the Board of Commissioners on May 12, 1916, and before the aldermen on June 22.

When some of the aldermen suggested that these engineers should have an investigation and report made free of cost to the city, the proposition was accepted. The 31 taxpayers selected a committee, made up of W. S. Tye, chairman, Sir John Kennedy, Ernest Marceau, J. A. Jamieson, R. A. Ross, Arthur Surveyer and Walter J. Francis.

The report of this committee was presented and approved at a meeting of the taxpaying engineers on Nov. 13, of which Phelps Johnson was chairman, and H. M. Mackay was secretary. This report was laid before the mayor, Board of Commissioners and City Council of Montreal on Nov. 20. The situation as presented in the report of this committee may be briefly summarized as follows:

So far as the city's water-supply is concerned, the original aqueduct was ample. The whole work must be viewed solely as a project for power development. The project which the city has undertaken is substantially the building of a canal, about five miles in length, to bring water to a power house where it would be discharged under a head probably not greater than 25 ft. This canal would furnish water enough to develop about 14,000 hp. in summer and about 7,000 hp. in winter, when the canal is covered with a thick sheet of ice. Troubles from frazil would probably reduce the winter output much below 7,000 hp. and cause complete shutdown of the plant more or less of the time every winter. This was the previous experience with the hydraulic power formerly in use at the city's pumping plant.

As another illustration: The 10,000-hp. hydro-electric plant of the Lachine Rapids Hydraulic Power Co., situated on the same rapids and less than two miles away from the aqueduct intake, is practically closed down for three or four months every winter. Conditions at the intake of this plant are similar to those at the proposed city power plant, and the facilities for removing frazil and other ice at the Lachine plant are much superior to those at the city intake, where no means whatever have been provided for this purpose.

Further than this, the engineers point out that the tail-race of the city power plant as now designed cannot safely discharge water for the development of more than about 6,000 hp., and no estimates whatever have been made for dredging in the St. Lawrence River below the outlet of the tailrace, which dredging would be necessary for about half a mile.

The first estimate of cost prepared by Mr. Janin was $4,975,000. The city has already spent nearly $5,000,000, and it will require at least $5,600,000 more to complete the project. This estimate does not include the cost of works for water filtration, of pumping plants and steam auxiliary plants, nor claims by one of the contractors amounting to over $900,000. Neither does it include any allowance for parking, nor the usual allowance for contingencies.

As an instance of the inadequacy of the original plans and estimates, the concrete retaining walls at first designed for the canal were found too light and had to be redesigned at an estimated increased cost of $675,000.

For the money that this project will cost, the City of Montreal could have purchased and developed any one of a number of water powers within easy transmission distance of Montreal, each of which has a capacity of at least 100,000 hp.

If the City of Montreal carries out and completes the present power plant, it will represent an investment by the city of at least $1,515 per horsepower capacity. In contrast with this, the 125,000-hp. hydro-electric plant built by the Laurentide Paper Co. at Grand' Mère, Quebec, cost only $52 per horsepower. The great plant at Cedar Rapids cost only $90 per horsepower, and when developed to its ultimate capacity this will be reduced to $75 per horsepower. The plant at Shawinigan Falls cost considerably less than $100, and the additional power developed there cost only $50 per horsepower.

It was not necessary for the city, however, to undertake its own power development. At any time during the last 15 years the city could have purchased power in the open market sufficient for all municipal purposes at a small fraction of the cost of its present power development. Twenty-four-hour power suitable for pumping can be purchased in Montreal for not more than $20 per horsepower per annum. The minimum fixed charges and operating expenses of the city's power plant now under construction will be at least $108 per horsepower per annum. The commission says: "The present project should never have been started, and we are firmly of the opinion that all thought of completing it along the present lines should be abandoned."

A National Industrial Conference Board has been organized to secure coöperative action in legislative and other matters by twelve important industrial organizations, including the National Association of Manufacturers and other organizations representing the foundry, metal and structural steel manufacturers, printers, the paper and rubber trades, and four of the leading textile organizations. Frederick T. Fish, of Boston, is Chairman of the Board, and Magnus W. Alexander, of West Lynn, Mass., is Manager. The organization of the board was announced at the 20th annual convention of the National Founders Association on Nov. 15.

Concrete Floor Falls After Early Removal of Forms

Disregard of the elements of safe reinforced-concrete construction has once more caused a concrete building collapse with fatal results and considerable material damage. Practically the whole roof of a large building under construction in New York City fell while the forms were being stripped from under concrete hardly a week old—a week, too, in which on four days the thermometer dropped below the freezing mark. The bare facts of the case are told as follows by E. B. McGuire, an engineer in the office of District Attorney Swann, who is now making an investigation of the collapse and has placed the facts before the Grand Jury. The district attorney's office furnished the photographs herewith:

"The concrete roof of a building being constructed by George G. Wilson & Co., Inc., of 25 West 42nd St., New York City, for the Havre Holding Company, Inc., of 141 Broadway, situated on the southeast corner of 64th St. and Third Ave., New York City, collapsed about eleven o'clock on the morning of Nov. 23, 1916. One laborer was killed and several others severely injured. The men were on the floor below at the time, engaged in stripping the forms and supports from the roof slab. Débris falling to the street below injured a woman and child. The entire upper floor will probably have to be replaced.

"The structure is a three story and basement corner building, 100 ft. wide on Third Ave. and extending down 64th St. 130 ft. The first or ground floor is fitted up as stores, the second and third floors being intended for garage purposes. The exterior walls, two elevator inclosures and fire wall around the main stairway inclosure on east end of building extending to 64th St. side, are of brick, and the small stairway on south side is inclosed in firebrick.

"The main structure is of reinforced concrete, a special type of girderless floor construction being used. This comprises circular straight rodded columns carrying the usual conical capital and dropped head but having also a shallow wide beam between columns. Wall columns were 12 in. square. Typical roof panels were 21 ft. 9 in. by 22 ft. 10 in. with the following dimensions:

Diameter of columns	12 in.
Diameter of capital head	6 ft.
Width of cross-beam	10 in.
Height of capital	3 in.
Total thickness drop head	10 in.
Total thickness cross-beam	6 in.
Total thickness slab	4 in.

"That portion of the roof between the fire wall and the east end of building is supported on reinforced-concrete beams about 10 in. deep and 10 in. wide, approximately 6 ft. 6 in. on centers. This part of roof shows no injury. The roof covering, which was in place, consists of a 6-in. cinder fill, sloped toward the east and west to provide drainage, the intention having been to finish it off with mortar topping.

"The collapsed portion of the roof extends from the southerly wall for a distance of about 73 ft. to the edge of the square slabs over the first row of columns on the north side and from the front of the building to the rear wall. The part of roof still standing on the northwest corner of the building has been moved from its original position and now overhangs a foot or more over Third Ave. Only three main columns supporting the roof have not been crushed or show bad fractures and distortions; one at each elevator shaft and the intermediate column.

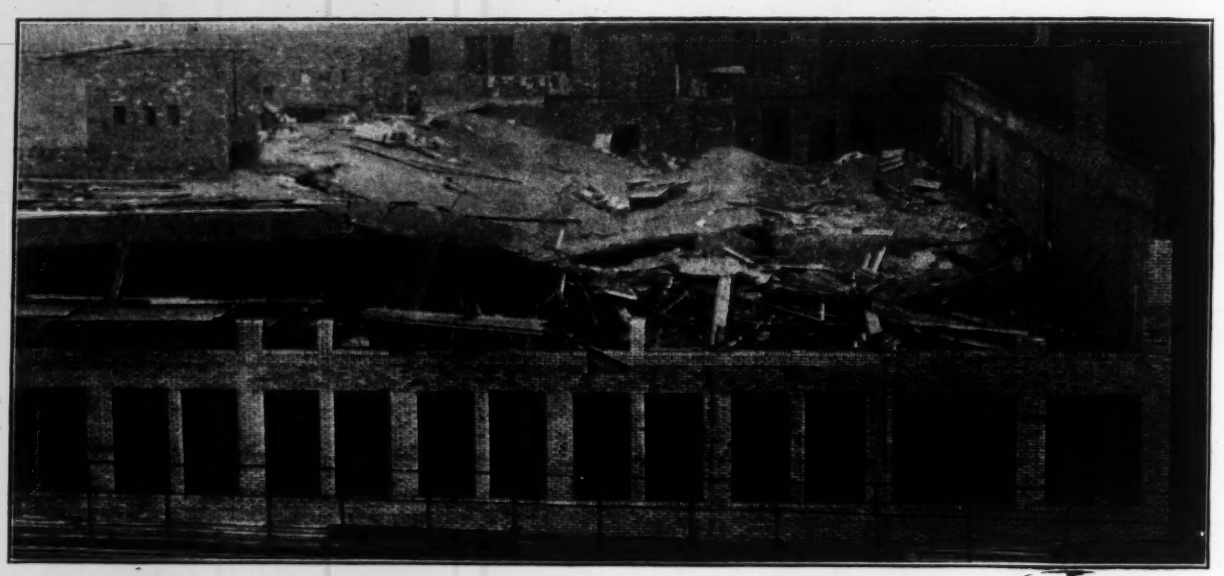


FIG. 1. LOOKING EAST FROM THIRD AVE. ON COLLAPSED SECTION OF ROOF

"The third floor and columns supporting it evidence no signs of cracks or injury from the impact of the fall.

"From the information at hand it appears that the men began pouring the roof on Nov. 9 and finished on Nov. 16, starting from the easterly side and working toward Third Ave. They began removing forms on Nov. 16 at easterly end, and this was in progress when the accident happened on Nov. 23."

A later investigation of the building and its design by a member of the editorial staff confirms Mr. McGuire's report except in regard to the time of beginning the roof form stripping. This date will probably be brought out in the inquest, but evidence now at hand seems to show that the form stripping started Nov. 21, the concrete at the east end then being not quite two weeks' old and on Nov. 23 reached the west end of the

FIG. 2. LOOKING NORTH ALONG THIRD AVE., SHOWING ROOF PULLED AWAY FROM BRICK WALL AT ELEVATOR SHAFT

roof where the concrete was barely one week old. The Weather Bureau report of temperature during this period is as follows:

DAILY TEMPERATURES AT NEW YORK CITY, NOV. 10-23, 1916

(Degrees Fahrenheit)

Nov.	Max.	Min.	Mean
10	60	47	54
11	54	45	50
12	52	41	46
13	51	45	48
14	55	33	44
15	40	31	36
16	40	28	34
17	46	32	39
18	47	36	42
19	49	31	40
20	53	36	44
21	42	27	34
22	43	28	36
23	59	38	48

It appears that the collapse is to be made the subject of rigid inquiry and perhaps of criminal prosecution, so that more than a preliminary or cursory report on it is not now feasible. The design will be examined closely, but at present that is a secondary consideration when it is recalled that the third floor, of similar design and about four weeks old, safely carried without underpinning—the struts having been removed from under it—the impact of the whole falling roof. This also exonerates the concrete of that section from criticism. The roof concrete on Nov. 26 after two weeks' setting appeared to be satisfactory, but eye witnesses state that on the day of the collapse the firemen cut into this same roof concrete with their axes as though it had been clay. While the trial or inquiry may bring out unexpected facts, the collapse now appears to have been due to criminal conlessness or ignorance in the removal of shores under concrete which with the best of conditions could hardly have reached a safe set but which with the prevailing weather was not concrete at all but merely a potential concrete awaiting time and warmth to make it solid.

The collapse was progressive. The initial failure was about the middle of the brick wall shown at the right of Fig. 1, and the first four rows of columns are all down. From that line north the columns all have a gradually decreasing inclination, but all bow out to the west.

FIG. 3. LOOKING SOUTH LONG THIRD AVE., SHOWING LEANING WALL COLUMNS

FIG. 4. ONE OF THE REMAINING COLUMNS UNDER ROOF

FIG. 5. BENT INTERIOR COLUMN UNDER NORTH END

Velocity Coefficients for a Dredged Drainage Canal

By Paul V. Hodges*

In the article entitled "Some Better Kutter's Formula Coefficients," *Engineering News*, Feb. 24, 1916, the following paragraph was noted:

> Experience shows that the coefficient of roughness for excavated channels of the same slope and cross-section is dependent upon the method of excavation. Additional experiments are needed to determine the specific coefficients for channels in earth excavated by different methods of dredging, etc.

The purpose of this article is to present the coefficients obtained on the Blitzen canal in Oregon and to show the adaptability of different formulas to the flow in this particular class. The results of this experiment show that Bazin's formula applies to the flow in this canal better than the other well-known formulas, but that the formula

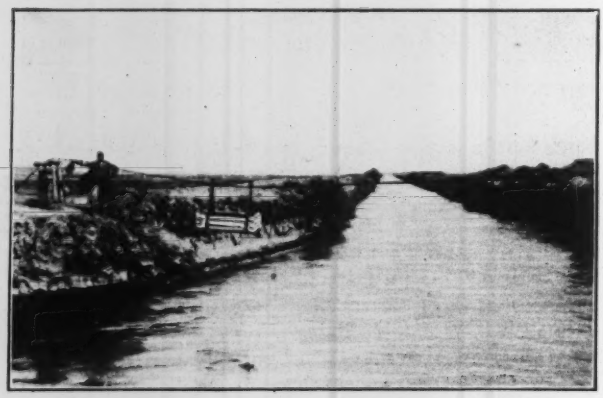


FIG. 1. BLITZEN CANAL SLOPE-STUDY COURSE

$V = 229.6\ (RS)^{0.68}$ derived for this canal applies somewhat closer than Bazin's. The average value of n in Kutter's formula was found to be 0.0255.

The Blitzen drainage canal, with a length of 25 mi., is located near Narrows, Ore., and was built to carry off more directly the total flow of the Donner und Blitzen River, thus partly reclaiming 20,000 to 25,000 acres of tule swamp. At Grain Camp, about 5 mi. from the lower end of this canal, headgates are installed to hold the water at the proper height for diverting to irrigation ditches. The canal was excavated, in a surface peat soil underlain with clay, by means of a floating dipper dredge with a bucket capacity of about ¾ cu.yd. The section as originally excavated was as nearly rectangular as it was possible to make it. At the present time the sides are somewhat irregular, being vertical or overhanging, as a rule. Many lumps or blocks of peat have fallen into the channel, thus causing more resistance to the flow, but the canal has been pretty well evened up by the floods that have passed through it since its completion.

The United States Geological Survey gage is located in the pool directly below the Grain Camp headgates, and the cable installation for making discharge measurements with the current meter is 100 ft. downstream, as shown in Fig. 1. Three thousand feet below the gage a benchmark is set, which is used for the determination of the elevation of water surface at Station *B*. Fig. 1 shows the canal looking downstream from the Station *A* to Station *B*. Two cross-sections were measured, as shown in Fig. 2—one near the gage, or at Station *A*, and the other at Station *B*. The average of these two cross-sections was used in the computations.

The readings of the water surface were somewhat inaccurate on account of small wave action; for this reason the gage readings at Station *A* were assumed correct, and the readings at Station *B* were corrected to show a uniform increase in slope with increase of gage height. This is shown in Fig. 3, in which the gage heights are plotted as ordinates and the slopes as abscissas. For example, the points as plotted for Station *A* are moved horizontally, as shown by the arrows, so that they will fall on the curve. This changes the slope values, and from these new values the elevation of water surface at Station *B* is computed. The measured area of cross-section and the wetted perimeter were corrected to comply with the correction for the elevation of water surface noted before.

In Fig. 4 are shown the rating curves for both stations. The measurements of discharge were made carefully with a small Price current meter. Readings of depth and velocity were taken at 2½-ft. intervals, from the cable at high stages and by wading at low stages. The velocity was obtained by taking readings at 0.2 and 0.8 of the depth at each section. The mean velocity at each vertical was taken as the average of these two readings.

In testing the application of different formulas to the flow in this channel the coefficients in the following formulas were computed from the data obtained in this experiment, as shown in Table 1. The coefficient n of Kutter's formula varies from 0.0253 to 0.0259, and the velocity as computed with these values has a variation of 2½% within the range of this experiment. The coefficient m of Bazin's formula,

$$V = \frac{87}{0.552 + \frac{m}{\sqrt{R}}}\sqrt{RS}$$

varies from 1.127 to 1.164, and the velocity as computed with these values has a variation of 2%. The coefficient C in the exponential formula $V = CR^{0.67}S^{0.54}$ varies 4%.

To obtain a formula that applies more closely to the law of flow in this canal the formula $V = K(RS)^{0.68}$ was derived, in which $K = 229.6$. The value of the coefficient K varies 1.8% within the range of this experiment.

*Junior Engineer, United States Geological Survey, 403 New Post Office Building, Denver, Colo.

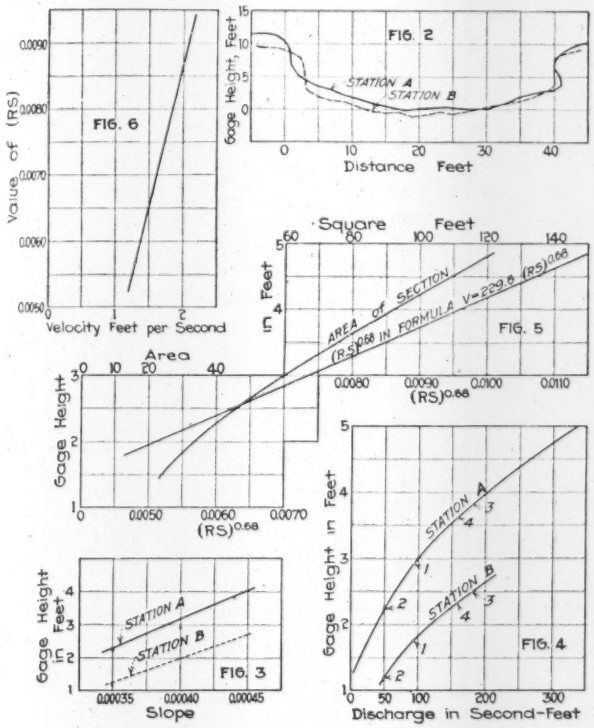
BLITZEN DRAINAGE CANAL AT GRAIN CAMP, ORE.

Station	No.	Date, 1916	Gage Height	Slope, S	Area Section	Average Area, A	Wetted Perimeter	Average Wetted Perimeter	Hydraulic Radius, R	Discharge, Q	Average Mean Velocity, V	Kutter Coefficient, n	Bazin Coefficient, m	Experimental Coefficient, c	Chezy, C	Blitzen, K	(RS)^0.68
A	2	May 4	2.23	0.000345	43.6	39.0	27.7	27.1	1.44	50.5	1.30	0.0257	1.127	75.41	58.3	229.4	0.005668
B	..	.....	1.19	.....	34.3	...	26.5	...	...	...	...	.....	....	....	...	....	.....
A	1	May 2	2.92	0.000386	64.0	57.6	32.5	31.6	1.82	94.0	1.63	0.0259	1.164	76.07	61.5	227.2	0.007173
B	..	.....	1.76	.....	51.1	...	30.8	...	...	...	...	.....	....	....	...	....	.....
A	4	June 10	3.60	0.000425	88.0	78.6	37.2	35.9	2.19	158	2.01	0.0253	1.138	78.66	65.8	231.4	0.008686
B	..	.....	2.32	.....	69.2	...	34.6	...	...	...	...	.....	....	....	...	....	.....
A	3	May 23	3.80	0.000435	95.1	85.4	38.5	37.0	2.31	180	2.11	0.0253	1.148	78.68	66.6	230.6	0.009151
B	..	.....	2.49	.....	75.6	...	35.5	...	...	...	...	.....	....	....	...	....	.....

It has been contended by some writers that the value of n decreases as velocity or hydraulic radius increases, the condition of the channel remaining the same. The results of this experiment show this to be true in this canal.

Additional experiments are needed to show the law of variation of n in Kutter's formula and m in Bazin's formula with a change in velocity or hydraulic radius for different classes of canals. In Bulletin 194 of the United States Department of Agriculture is a diagram showing the variation of n with velocity and hydraulic radius from experiments on many different classes of canals.

In Fig. 5 curves are drawn showing the relation between



FIGS. 2 TO 6. CROSS-SECTION, RATING CURVES, ETC., BLITZEN CANAL

the gage height and area of cross-section, and also gage height and values of $(RS)^{0.68}$. In Fig. 6 the relation between velocity and values of $(RS)^{0.68}$ is shown. Great care was taken in the measurements and computations, and the results are considered reasonably accurate. A larger range of stage in the measurements would have increased the value of the experiment, however.

The Municipal Electric-Light Plant of Wallingford, Conn., although a small plant of only about 600-kw. capacity, has shown remarkably good financial results, according to the annual report for the year ended July 31, 1916, just issued. The gross earnings last year were $52,000, and the net earnings $22,700. The balance sheet shows a total valuation for the plant at the present time of $280,000. The plant was built 17 years ago by an issue of bonds and it has earned profits since its construction sufficient to continually enlarge its capacity and to pay interest and sinking-fund charges on the bond issue, so that at the present time only $55,000 in bonds are outstanding, and there is $38,000 in the sinking fund. The accumulations of this fund in another year will be sufficient to wipe out the bonded indebtedness. The general manager of the plant, A. L. Pierce, in his annual report states that the plant has never, in the 17 years of its operation, received any money from the taxpayers. The total interruptions to service have amounted to 45 min. in 17 years.

City Managers Exchange Ideas

A unique convention program was carried out with eminent success by the City Managers' Association at Springfield, Mass., last week. Not a single formal paper was presented, yet a dozen subjects were quite fully discussed. This was the plan: There was a roll call on each subject. Responses were limited to five minutes, but some of the fifteen managers present took less, thus giving extra time to the few who needed it. The retiring officers—Henry M. Waite, of Dayton, and Ossian E. Carr, of Niagara Falls—kept the convention well in hand, even to starting most of the meetings on scheduled time when only two or three members were on the floor.

The city managers met first in New York City, where they put in a busy and instructive day visiting city offices and works, attending a dinner followed by addresses. At Springfield, round-table lunches and dinners merged into discussions, making virtually four sessions a day, and on the third day the City Managers' Association and the National Municipal League joined with representatives of still other municipal organizations at lunch, after which about a dozen managers told of their most notable achievements during the year. A part of an evening session was devoted to addresses on the public works of Springfield, Mass., followed the next morning by an automobile ride over the city.

Secretary Carr reported that city managership work is an extra-hazardous occupation, as 6 of 36 members of the association had retired from their positions during the year. There is still room for growth, as the number of cities committed to the city-manager plan has increased from about 70 to 90 during the year.

That the city managers stand for adequate budget making, constructive publicity, keeping themselves in the background, a large variety and amount of work for social as well as material improvement, the elimination of partisan politics, favoritism and corruption from municipal government, and that they work with untiring energy for these and all other ends making for efficiency was apparent from the discussions at the convention.

Many if not most of the managers are engineers, but the topics before the convention were, naturally enough, chiefly of an administrative rather than an engineering character. There was a round of expression of opinion regarding methods of cost keeping. This disclosed practical agreement on the desirability of cost keeping, with an apparent difference of opinion as to whether effort should be centered on the amount of work one man accomplishes in a day or the cash outlay for a unit of work. This seeming disagreement may have been due to momentary confusion over efficiency of employees and total cost of work done. One or two managers emphasized the difficulties that beset any attempt to secure unit-cost figures that are of real value for comparing one city with another, owing to differences in various local conditions.

How best to train city managers gave rise to some animated discussion. H. M. Waite was pronouncedly in favor of training in service rather than in any school or university, since the essential thing in a manager is executive ability.

The election of officers resulted in the choice of Ossian E. Carr, Niagara Falls, N. Y., as president, and W. L. Miller, St. Augustine, Fla., as secretary-treasurer. The next meeting place was left for future decision.

News of the Engineering World

Municipal Week at Springfield

With the growing number of technical and municipal conventions, hearty welcome will be given to every successful effort to bring as many of a kind together at one time and place as may be reasonably possible. A notable example of such effort was furnished last week, when the City Managers' Association, the National Municipal League, the Municipal Research Conference, the Training School for Public Service, the Civic Secretaries' Committee and the Intercollegiate Division of the National Municipal League, the Massachusetts Federation of Planning Boards and the Massachusetts Civic League met at Springfield, Mass. A number of these organizations held one or more sessions in common, besides which there were numerous joint lunches, dinners, and, to give full measure, a joint breakfast, followed by discussions of common interest.

A brief report of the meeting of the City Managers' Association appears elsewhere in this issue. The other conventions, while discussing numerous vital municipal questions, brought out little of direct interest to engineers. There was, it is true, considerable discussion of city planning, but this related mostly to topics already presented in *Engineering News*.

Progress of Federal Aid for State Highway Work

The Secretary of Agriculture has interpreted the Federal aid highway law to mean that in accepting the terms of the act a state, as a matter of course, pledges its faith to a five-year program, because the Federal Government will furnish aid during a five-year period. This he regards as important because it makes possible the arrangement of a comprehensive scheme of road building. The expenditure of the entire amount of money contemplated under the act is to be planned at the outset, so far as possible.

California is the only state as yet which has met every requirement of the law. Georgia and Maine have complied with all requirements except the submission of a general program of road improvements. In Connecticut, New Hampshire, Pennsylvania, Idaho and Louisiana, the pledge of the faith of the states to match the Federal appropriations for five years have not yet been given, but is expected soon. In New York, Vermont and Wisconsin, further legislation is considered necessary by their officials before the Federal coöperation can be utilized. In Virginia, where the State Highway Department has no authority to submit a state-wide project for road improvements, the pledge of the faith of the state to the terms of the act and the submission of a five-year road-building program are particularly difficult matters to adjust.

The states with which formal negotiations looking to early participation in Federal aid have not yet been carried on are Arkansas, Delaware, Florida, Illinois, Indiana, Kentucky, Maryland, Mississippi, Nebraska, Nevada, New Mexico, North Carolina, Ohio, South Dakota, South Carolina, Tennessee, Texas, Utah, Washington, West Virginia and Wyoming. Informal correspondence shows that many of these states will be in a position to take up the subject formally before long. The Office of Public Roads and Rural Engineering has prepared a state highway bill for the consideration of the Texas legislature and is coöperating with the Oregon Association of County Judges in the preparation of an entirely new road law for that state. Drafts of road bills are being prepared for South Carolina, South Dakota and Nevada at the request of officials of those states.

New Jersey Highway Engineers Tackle Motor-Truck Problem

The second and final hearing of the special committee, appointed by the Commissioner of Motor Vehicles of the State of New Jersey, for the purpose of preparing rules and regulations to govern the use of motor trucks on the highways of the state was held in Newark, Nov. 24. About 100 persons were present and the session was lively and full of interest.

The committee has been studying the problem since May of this year, and for the particular purpose of devising means of saving the roads from destruction. New Jersey being the first state to enter upon systematic highway improvement, it follows that the facilities for studying the effect of motor-truck traffic on the older types of highway pavement are about the best. The chairman of the special committee is Thomas J. Wasser, a civil engineer of Jersey City, and the secretary is Frederic A. Reimer, county engineer of Essex County.

Some of the rules the committee proposes are: To allow no vehicle over 96 in. wide to use the roads without a special permit; to limit the height of vehicles to 12 ft. 2 in., and the length to 26 ft. 6 in.; to prohibit the use of any motor vehicle or trailer with metal tires, or tires with lugs or hobs, etc.; to require every vehicle to be equipped with a sealed governor or other automatic speed control; to allow the use of a single trailer only; to prevent a truck with tires so damaged that the metal rims come in contact with the road from being moved, under a penalty of $500 for each violation; to require a name plate giving the maximum speed and gross weight (loaded) of the vehicle; to make motor-truck owners directly responsible for damage done to bridges where the weight of the loaded truck exceeds the posted safe load for the bridge, and to appoint state inspectors to enforce these rules and regulations by actually testing the speeds and weighing the trucks if necessary.

It is proposed to base all license fees on the maximum wheel load, according to tables compiled from data furnished by rubber-tire manufacturers as proper loads for each size of tire. By the proposed rules separate licenses would be required for tractor and trailer; one-third the gross weight of a truck and its carrying capacity would

be such as not to exceed a schedule which also specifies the size of wheel, tire and the speed for each in miles per hour. Thus the maximum wheel load is fixed at 8,625 lb., on two 7-in. tires on 42-in. wheels, and the speed of such a vehicle would not be allowed to exceed 10 mi. per hr. Pneumatic-tired vehicles it is proposed to license as pleasure vehicles and they would not be classed as trucks.

There was much objection made by the motor-truck representatives to the provision requiring rubber tires. A tire manufacturer stated that rubber tires were not now made in larger diameters than 42 in. A severe penalty for speeding was suggested in place of the requirement of sealed governors, which it was said were imperfect and difficult to keep in order. It was said that the speed limit of 10 mi. per hr. was too low for economical operation, that 15 mi. per hr. should be fixed. There was a repetition of the general arguments against discriminatory fees, such as were noted in last week's report of the New York State hearing on motor-truck fees.

Miami Flood-Prevention Plan Approved by Court

Dayton, Hamilton, Middletown and other Ohio communities in the Miami River valley are to be safeguarded against devastating floods by detention reservoirs and channel improvements. The plan approved is the one described in *Engineering News* of April 6, 1916, as having been adopted by the directors of the Miami Conservancy District. (Edward A. Deeds, president; Arthur E. Morgan, chief engineer; office, Dayton, Ohio.)

To become effective this plan had to be authorized by the county judges of the nine counties included in the district, sitting as a Conservancy Court. The long hearing before this court was reviewed by Col. H. M. Chittenden, one of the consulting engineers to the district, in *Engineering News* of Nov. 9, 1916, and on p. 906 of that issue a map of the district, showing the five detention reservoirs, was printed.

The vote for approving the plans stood 7 to 2, the two adverse votes being limited to dissent as to the need for one of the five reservoirs. On some other points at issue there were also various minority dissenting opinions, but all these were waived in the final approval. The court was unanimous as to the combination of dry detention basins and channel improvements being the only "practical and efficient plan of protecting the Miami valley from the results of defective floods." The full decision follows:

1. The court is of the opinion that the question raised as to the constitutionality of the law by reason of the decisions in the cases of Baumann vs. Dayton in the 66 O. S., and commissioners vs. Gates in the 83 O. S. is not now properly before the court for the reason that it does not appear that any assessment has been made against any specific piece of property and that therefore no one is now in a position to complain; and for the same reason other questions as to the unconstitutionality of the act on account of the method provided for the raising of funds is not now before the court.

To this finding Judge Mathers dissents.

2. The court is of the opinion that the Miami River is not a navigable stream in law or fact.

3. The court is of the opinion that any obstruction that may occur from the adoption of the plan to the public use or navigation of the Miami and Erie canal is authorized by the contract between the conservancy board and the state officials as provided for in the conservancy act.

4. As to the objection that no construction shall be made under the authority of the act which will cause the flooding of any village or city unless the board shall have acquired and paid for the right to use the land affected for such purpose and shall have paid all damages incident thereto, the court is of the opinion that such provision of the law does not prevent the adoption of the official plan.

5. The court is of the opinion that channel improvement alone for the entire conservancy district is not feasible or practicable, and is prohibitive in cost and would not adequately protect the district from flood waters.

Judge Mathers dissents from the proposition that channel improvement alone would not adequately protect against floods.

6. The court is of the opinion that the combination of dams and dry detention basins, together with channel improvement, is the only practical and efficient method of protecting the Miami valley from the results of destructive floods.

7. The court is of the opinion that earthen dams, with concrete conduits and spillways as provided for in the official plan, are safe and will be of sufficient strength to sustain at all times any burden that may be placed upon them by impounded water.

Judges Jones, Mathers and Kyle do not fully concur in the foregoing, but find that a preponderance of the evidence shows that the dams as provided will be reasonably safe.

8. The court is of the opinion that it would not be feasible to reduce the height of the Huffman dam or its spillway.

To this Judges Kyle and Geiger dissent.

9. The court is of the opinion that the Lockington dam should not be eliminated from the official plan.

To this Judges Jones, Mathers and Geiger dissent.

10. The court is of the opinion that the objections filed to the official plan as proposed by the board of directors of the conservancy district should be overruled; that the work proposed in said plans is necessary and that the same will be conducive to and conserve the public health, safety, convenience and welfare of the Miami conservancy district, and the court therefore adopts the said official plan.

To the judgment of the court adopting the official plan, Judges Jones and Mathers dissent by reason of the finding made by the court in the ninth syllable hereof refusing to eliminate the Lockington dam; otherwise concurring with the majority of the court.

The estimated cost of the project is $23,540,000, including $4,000,000 for contingencies.

While means are provided for an appeal, it is thought that the work of the district will go forward without further delay. However, construction can not be started yet as the law requires the appraisers to report, and their report to be reviewed and approved by the court, before construction work can begin. The whole question of the advisability of the conservancy project may, in fact, be reconsidered at that time, and the plan rejected or modified. This in effect gives the objectors a second hearing without resorting to appeal to a higher court.

Columbus River Widening for Moderate Floods

Under rather unusual instructions from the city council, Chief Engineer Henry Maetzel, of the engineering department of Columbus, Ohio, is making estimates of cost for two river-widening plans, for increasing the flood-carrying capacity of the Scioto channel through the city. This scheme is independent of the larger flood-prevention project which was worked out by Alvord & Burdick, as engineers for the Franklin County Conservancy District.

The conservancy project, which comprises large detention dams and a considerable amount of channel improvement, will be heard before the Franklin County judges sitting as a Conservancy Court on Dec. 6. It is opposed by many residents of the region, and for this reason an opposition scheme was launched in Columbus a few months ago, contemplating only a moderate channel widening through the city

The advocates of this scheme proposed to widen the channel to 580 ft. from the confluence of the Scioto and Olentangy down to Greenlawn Ave., about 2½ mi. They

claimed it would cost the city $3,500,000, and would carry floods greater than that of 1913 (which was 140,000 sec.-ft.). A referendum vote in November authorized the council to expend 3½ million dollars in channel widening.

An earlier investigation having indicated that the proposed channel would carry only 80,000 sec.-ft. and would cost more that its advocates claimed, the city council on Nov. 13 directed the chief engineer to make plans and estimates for two channel-widening schemes, one for a 580-ft. channel, and one for a channel to cost 3½ million dollars. Preliminary studies for this are now being made by R. H. Simpson, under Mr. Maetzel's direction.

The length of river channel under study is about 3¼ mi., extending downstream from the confluence of the rivers. Much land will have to be acquired. New levees must be constructed for over half the length, and a large amount of retaining-wall work is needed.

An unusual phase of the matter is that a project for channel improvement (but to a much larger capacity) was rejected by the voters of the city in 1913. It received a bare majority, but as a two-thirds vote was required to ratify a bond issue the proposal failed. This involved a much higher cost than the present 3½ million dollar project. The failure of that proposal led to the organization of the Conservancy District, and to the subsequent development of a detention-basin project as being much cheaper and of broader benefit than pure channel improvement.

Concerning the city studies now under way, information from several well-informed sources indicates that the 580-ft. project will cost over 50% more than first estimated, and thus will approach near to the cost of the entire conservancy plan, while giving protection only against normal floods, but bound to fail under calamitous floods. No opinions are obtainable as to what flood-capacity can be secured for the 3½ millions authorized.

Ontario Power Commission Will Develop Chippewa Creek

The Ontario Hydro-Electric Commission, it is reported, has decided to undertake forthwith the construction of the projected canal between Chippewa Creek (which flows into Niagara River above Niagara Falls) and Queenston for the supply of 200,000 hp. of electrical energy for the provincial hydro-electric power-distribution system. The work will be carried on under the direct control of the commission, as contractors were not disposed to tender except on the basis of the probable advance in the cost of fuel and on an estimate of 25% over cost as profits. The commission proposes to procure electric-driven excavating machinery, so as to avoid the uncertain element of fuel cost, and to save labor. It is estimated that the electrical equipment will cost between $800,000 and $900,000, as it will call for general excavation machinery of the heaviest type. The cost of the entire construction of the canal, which will be 12 mi. in length, is estimated at $9,000,000.

At a joint meeting of the Ontario Hydro-Electric Railway Association and the Municipal Electrical Association of Ontario, the following resolution was adopted:

It is hereby unanimously resolved that the Ontario Government be asked to pass an order-in-council forthwith, permitting the Ontario Hydro-Electric Power Commission to exert its functions and powers in expropriating the plant or product of the Canadian Niagara Power Co. and others developing power at Niagara Falls.

Conference on Education in Highway Engineering

Plans have been perfected for a national conference to discuss highway engineering instruction in the civil engineering curricula of universities and colleges. The meeting is to be held Dec. 29, at 8:30 p.m., in the assembly hall of the Automobile Club of America in New York.

The conference is to be held under the joint auspices of the Society for the Promotion of Engineering Education, the American Association for the Advancement of Science, the National Automobile Chamber of Commerce, the Automobile Club of America and the National Highway Association. The papers presented and the discussions upon them will be published in the *Proceedings* of the Society for the Promotion of Engineering Education.

Arthur H. Blanchard, Professor of Highway Engineering at Columbia University and Secretary of Section D, Engineering, of the American Association for the Advancement of Science, has undertaken the work of organization.

Chicago Sewage Treatment and Dilution

Important improvements in the sewage-disposal system of Chicago are to be carried out under an order passed Nov. 23 by the Board of Trustees of the Sanitary District of Chicago. This order directs the chief engineer to prepare plans and specifications for works recommended in a report presented by the Committee on Engineering and designed to improve the condition of those streams within the district that now receive crude sewage. This not only pollutes the water and makes proper dilution difficult, but also causes deposits that are offensive and tend to check proper flow. The works proposed would improve conditions in the north and south branches of the Chicago River, the Drainage Canal (and Sag Channel), the Desplaines River and the Illinois River. With the solids excluded, the disposal of the effluent and the maintenance of the streams in proper condition would be very much simplified. The necessity for this removal of solids before sewage is discharged into the Sanitary District channels has been evident for some time and has been made the subject of extensive investigation. This applies particularly to the stockyards and packing-house section.

A large amount of sewage from suburban towns is now discharged into the Desplaines River, causing offensive conditions and destroying the use of the river for fishing, ice-cutting and pleasure purposes. This sewage, in an advanced state of putrefaction, then flows into the Illinois River. Similar conditions exist in the north branch of the Chicago River, where the amount of diluting water is limited. The remedy lies in collecting the sewage and delivering it to points where the solids can be removed and any other necessary treatment given. The Sanitary District is already operating works at Morton Grove for the removal of solids from the sewage before it is discharged into the north branch of the river.

The report makes plain the committee's view that the treatment recommended for the removal of solids and further purification of the sewage is only supplementary to the dilution and for the purpose of rendering this latter more effective. The Sanitary District Act (1889) re-

quires a continuous flow of at least 20,000 cu.ft. of water per minute for each 100,000 inhabitants of the district. It also requires the removal of solids before sewage is discharged into the channel, and the maintenance of the channel in such condition that the water will be neither injurious to health nor offensive. The committee states that it does not consider it practicable to dispose of the sewage properly without this amount of diluting water.

The report recommends the purchase of land and preparation of plans and specifications for the several proposed works. The recommendations may be summarized as follows:

1. The construction of intercepting sewers along the Desplaines River to collect the sewage of Maywood, River Forest, Forest Park, etc. (now discharged into the river), and the treatment of this sewage by an activated-sludge plant.

2. The treatment of domestic sewage centering at the 39th St. pumping station (from an area of about 22 sq.mi.) by settling basins or an activated-sludge plant in the vicinity of this station.

3. The treatment of sewage from the Calumet region, which will be diverted through the new Calumet intercepting sewer to the Calumet-Sag Channel.

4. The treatment of sewage from Evanston, the north-shore towns and the district along the north branch of the Chicago River. Specific study should be made of methods for remedying the local nuisance now existing in the north branch of the river, where the flow of water is insufficient to maintain scouring velocities.

5. The extension to the Drainage Canal of the sewers east of 52nd Ave. which now discharge into the Ogden Ditch. Negotiations should be taken up with the city authorities for apportioning the cost between the Sanitary District and the City of Chicago.

The Estimated Population of the United States on Jan. 1, 1917, will be 102,826,000 persons according to the statistics of the Census Bureau based on the Federal census of 1910, with a rate of increase computed on the increase recorded from 1900 to 1910. This is for continental United States. The outlying possessions of Alaska, Guam, Hawaii, Canal Zone, the Philippines, Porto Rico and Samoa bring this figure to 113,309,000.

A Sewer Manhole Cover in State St., Boston, was recently lifted by the teamster of a coal truck who mistook it for the cover to a coalhole and proceeded to dump a large load of coal into the sewer. Just as the last of the load disappeared into the manhole the mistake was discovered, and a hurry call was sent to the Public Works Department. Prompt work by the emergency crew cleared the sewer before the flow in it had backed up enough to do damage.

Flood Lighting of the Statue of Liberty in New York harbor is to be inaugurated on the evening of Dec. 2, at the beginning of the "Electrical Celebration Week," when elaborate ceremonies in connection with the rededication of the statue are to occur. The ceremonies in connection with the completion of the statue took place thirty years ago, on Oct. 28, 1886. The statue was under construction a long time previous to that date however. The hand holding the flaming torch was one of the exhibits at the Centennial Exposition in 1876.

The John Fritz Medal, awarded in January, 1916, to Dr. Elihu Thomson for achievements in electrical invention, in electrical engineering and in industrial development and scientific research, will be presented to Dr. Thomson at a meeting to be held in Boston on Friday evening, Dec. 8, the ceremony taking place in the Central Lecture Hall of the new buildings of the Massachusetts Institute of Technology. The program will include addresses by John J. Carty, E. W. Rice, Jr., and R. C. MacLaurin. The presentation will be made by Charles Warren Hunt and the ceremonies will conclude with the response of Dr. Thomson.

The Floating Bridge in the City of Lynn, Mass., on the Salem-Boston turnpike, described in "Engineering News," May 4, 1916, is likely to be replaced with a modern structure, according to a report in the Salem "Evening News." The bridge crosses a pond 17 acres in area, underlain by a deep bed of peat. The bridge was originally built of three layers of pine logs laid at right angles to each other and secured together by 3-in. dowels. Additional timber has been added at various times during the century and over, since the bridge was first built, but the whole mass is so water-logged that under a heavy load the bridge gradually settles until the water flows over the floor. When the Salem batteries went to Framingham last June, they were obliged to make a long detour instead of crossing this bridge.

A 36-In. Water Main Broke in Minneapolis at 10:45 p.m. on Nov. 21, making it necessary to shut off the supply from the Camden station which feeds the south and north sections of the city. The east side was unaffected, that section being fed by a 48-in. main from the filtration plant. The remainder of the city is supplied by a 50-in. main which runs from the filtration plant to the Camden pumping station and is distributed thence over north and south Minneapolis by means of three smaller mains of which the 36-in. pipe that broke was the largest. The hole made was 16 ft. deep, 30 ft. wide and 35 ft. long. The repair crew got on the job quickly, but it was not until about 7 a.m., Nov. 22, that pressure was restored. Two months ago this same main broke under similar circumstances only a few joints distant from the present break.

A Settlement of Differences between the City of St. Louis and the local traction system, the United Railways Co., has been proposed by the latter in an open letter to the City Board of Estimate and the Public Utilities Committee of the Board of Aldermen. The company asks that the city repeal the mill-tax ordinance and drop its suits attacking the validity of the system's franchises. The company agrees to pay the mill tax to Dec. 31, 1916, and any more reasonable tax after that date. The company claims that the mill tax (equivalent to 2% of gross earnings) is such a burden that proper service cannot be given under it with present operating expenses. The city suits have clouded the franchise so that new capital cannot be secured. The proposal for a settlement and the accompanying arguments were published as full-page advertisements in the local papers.

The New York Barge Canal, according to the "Barge Canal Bulletin," has $68,700,000 worth of work done on contracts completed and $13,500,000 worth of work done on contracts now in force with about $4,000,000 worth of work remaining to be done on these latter contracts. On the canal terminal work, the preliminary contracts for dredging, dock walls, grading, etc., for 46 terminals have been awarded and construction is under way with about $1,500,000 already expended. In connection with an extended discussion in the report on the barge canal terminal problem, it is stated that the results of a careful investigation two years ago showed that the average terminal charge on freight transported by water in the United States was equal to the cost of carrying the cargo 2,500 mi. On the Great Lakes, where terminal costs have been reduced to the lowest figure by the extensive introduction of machinery for terminal handling, the terminal charge on the cargoes is still about equal to the carrying cost for the 1,000 mi. which the goods are transported by water.

Rebuilding Lower Otay Dam—The question of the validity of the bond election held by San Diego, Calif., on Nov. 17, for the purpose of rebuilding the Lower Otay dam will probably be immediately brought before the supreme court for a decision. In the election the proposition for bonding the city in the amount of $682,200 for rebuilding the dam carried two to one. Included in the same election, however, although on a separate ballot, was a proposition to grant 500 acres of tidelands to the United States Government for military purposes. Many people who voted on this question failed to vote on the bonding proposition. For this reason the Lower Otay bonds did not receive a two-thirds majority of the total vote cast at the election, which many claim is necessary to carry the bonding proposition. The city attorney, however, holds that the bonds will stand, since the granting of the tidelands to the government was not a bonding question, and will bring friendly suit to have the supreme court make a decision in the matter, rather than call for a new election which will delay the work for several months. It is probable that the matter can be settled by the court within sixty days and at a cost not to exceed $50, while a new election would cost the city $6,000. In the meantime no money will be spent at the Lower Otay dam site.

Shipbuilding in the United States has developed during the past year on an enormous scale. Reports by shipbuilders to the Bureau of Navigation show that on Nov. 1, 1916, there were in American shipyards under contract or construction

417 merchant vessels aggregating 1,480,000 gross tons. Of this total, 163,000 gross tons were in shipyards on the Great Lakes, about 56,000 tons on interior rivers, 431,000 tons on the Pacific Coast and the remainder on the Atlantic Coast. The yard having the largest amount of work is the Union Iron Works, of San Francisco, which has 28 vessels aggregating 175,000 tons under way. The New York Shipbuilding Co., of Camden, N. J., has 26 vessels of 134,000 tons in its yards and under contract. These statistics do not include of course the very large tonnage of vessels for the navy, which are under construction in private yards as well as in the Government yards. Not only is the shipbuilding now going on far more extensive than anything ever before recorded in the United States, but the United States now leads all nations in its rate of construction of merchant vessels. The shipyards of Great Britain, which under normal conditions is the great shipbuilding country of the world, are now employed largely on Government work, and their construction of merchant vessels is further limited by the diversion of labor to the military forces and the munition plants.

The Daylight Saving Movement was reported on at the meeting of the American Railway Association in New York on Nov. 15. The Association's Committee on Standard Time, of which E. B. Thomas, President Lehigh Valley R.R., is Chairman, emphasized in its report that any such readjustment would have to be nation wide in order to avoid a great amount of confusion. The committee advised that the railways should take the following stand with reference to the question:

"1. That the present subdivisions, or zone system, of dividing time is scientifically correct.

"2. That any change in such subdivisions of time would result in endless confusion, and would be disastrous to the railroads.

"3. That in the event of a nation-wide movement to change the hands of the clock in order to readjust the hours of daylight to the hours of labor, the railroads should not antagonize the movement. It is the feeling of the Committee that the railroads will not suffer any very serious inconvenience nor disarrangement of schedules by the change as proposed, although such a change from a scientific standpoint is not warranted nor is the Committee in sympathy with the movement.

"The Committee feels that the railroads should not agree to the 'daylight-saving' project until it has been previously adopted by the principal business and municipal centers, together with the state and local authorities. Unless a change of the character proposed can be made on the same date throughout the country it will lead to great confusion and difficulty."

City Bridge Inspection and Repair—Apprehension over the safety of the bridges in Cleveland over the Cuyahoga River, which started when a runaway street car wrecked a bridge on West 3rd St., on Oct. 3 ("Engineering News," Oct. 12, 1916) has led the city authorities to order a general inspection of all the city bridges. This order is being carried out by F. D. Richards, Engineer of Bridges, Harbor and Grade Crossings under Robert Hoffman, Chief Engineer, and some remarkable results have followed. As soon as it was necessary to put up staging for the inspector's use, the iron-workers claimed that this must be done by union men, and it therefore became necessary to employ such a man in addition to the inspector. It was therefore decided to make repairs simultaneous with the inspection, replacing loose rivets or small broken parts. The inspection has been slow on this account, and up to now has covered only one bridge, the old Superior Street viaduct. This structure is badly overloaded. Its swing-span was thoroughly repaired and readjusted about four years ago, and has not deteriorated noticeably since then. Nevertheless the stresses under full loading by heavy street cars run up very high in some members, reaching 30,000 to 35,000 lb. per sq.in. in some of the eyebars under certain conditions. In view of this fact, which was known previously, the city authorities decided to so restrict traffic as to prevent close spacing of street cars on the iron spans. The restriction consists in stopping cars at the abutments when the draw is open or to be opened; this means keeping them three or four hundred feet back of the draw at the east end, where there are several fixed spans. The only risk due to close spacing of cars is believed to occur when the cars stop because of an open draw.

The Channel-Tunnel Project is again under discussion in Great Britain, and the "Engineering Review" (London) describes the project. The scheme dates back to 1874, when a French syndicate obtained a concession and sunk a shaft at Sangatte, near Calais, to the depth of the proposed tunnel and made experimental borings for a mile and a half under the sea. In 1881 the Southeastern & Chatham Railway Co. sunk a shaft at Dover and drove a 7-ft. diameter tunnel at a depth of 160 ft. for 2,015 yd. The Submarine Continental Railway Co. was later incorporated in England to further the enterprise and had driven over 2,000 yd. of tunnel when work was stopped on account of public agitation over the question whether the tunnel would not prove a source of military weakness. No work has been done since July, 1882, but the Channel Tunnel Co., Ltd., is still in existence, with Sir Douglas Fox & Partners as its engineers. The total length of the proposed tunnel would be about 27 mi. The greatest depth reached would be between 250 and 300 ft. below sea level. The plan of construction contemplates two parallel tunnels, each 18 ft. 5 in. in internal diameter, which is said to be large enough for the standard rolling stock of present French and British railways. The stratum through which the tunnel would be driven is said to consist of gray chalk. The tunnels would be driven with shields and lined with cast-iron plates. A separate drainage tunnel 9 ft. in diameter would be driven first. The two parallel tunnels would be connected by cross-galleries at intervals, but these would have air-tight doors. In addition to the longitudinal movement of air in the tunnel, induced by the trains running in the same direction, the air would be forced in at each end in the same direction as the traffic, so that perfect ventilation would be secured. The total cost of the British half of the tunnel is estimated at $40,000,000. The "Review" quotes Arthur Fell, Chairman of the Committee of members of the House of Commons in favor of the construction of the channel tunnel, as stating that the plans for construction are so far advanced that work could be commenced immediately, whenever the necessary legislation is secured.

PERSONALS

Allen Kisinger, formerly with the Water-Works Department of Cincinnati, Ohio, has been appointed City Engineer of Norwood, Ohio, succeeding John G. Schmidt.

W. J. Golden, former Manager of the Jobbing Department of the Lackawanna Bridge Co., Buffalo, N. Y., is now General Manager of the Ferguson Steel and Iron Co., Buffalo.

Oliver C. Sheley has been elected County Engineer of Jackson County, Missouri. According to a local newspaper his campaign expenses were $714 (about half a year's salary).

L. O. Marden, former Chief Draftsman of the city engineering department of Oklahoma City, has been made Chief Draftsman of the State Highway Department of Oklahoma.

M. C. Selden, recently Division Engineer of the Chesapeake & Ohio Ry. at Richmond, Va., has been promoted to be Trainmaster of the Rivanna district, with headquarters at Charlottesville, Va.

Arthur V. Farr, for the past three years Advertising Manager of the S. K. F. Ball Bearing Co., Hartford, Conn., has been appointed Sales Manager of the Hess Steel Corporation of Baltimore, Md.

Jerry W. Gwin, former County Engineer of Jefferson County, Alabama, has been elected President of the new County Board of Revenue, which has supervision over all the public works of the county.

George F. Leslie, formerly with the office of the United States Forest Supervisor at Northfork, has been transferred to the Office of the Engineer of Highways, Forest Service, District No. 3, at Albuquerque, N. M.

Manley Osgood, Assoc. M. Am. Soc. C. E., City Engineer of Ann Arbor, Mich., is President of the Washtenaw Engineering Co., which announces the opening of its offices at 408 First National Bank Bldg., Ann Arbor.

Landon M. Brooks has resigned from the employ of Norton, Bird & Whitman, Chicago and Baltimore, to become Engineer of Construction of the Electro-mechanical Co., of Baltimore, Md. He is a graduate of Cornell University.

A. C. Everham, M. Am. Soc. C. E., has resigned as Engineer of Construction of the Kansas City Bridge Co. to become Terminal Engineer at Kansas City of the Union Pacific R.R. Before going to the Kansas City Bridge Co. he was Assistant to the Chief Engineer of the Kansas City Terminal Ry.

Edward M. Bigelow, M. Am. Soc. C. E., former State Highway Commissioner of Pennsylvania, has been appointed Director of the Department of Public Works of Pittsburgh, Penn., succeeding the late Robert Swan. Mr. Bigelow has been Director of the Department of Public Works of Pittsburgh twice before, from 1888 to 1900 and from 1903 to 1906. He is credited with the construction of Grant Boulevard and has been called the father of Pittsburgh's notable parks. His salary will be $8,000 per annum.

Max L. Cunningham, Assoc. M. Am. Soc. C. E., formerly Consulting Engineer, Oklahoma City, Okla., has been appointed State Engineer of Oklahoma.

R. G. Wyman has been appointed Division Engineer of the Atchison, Topeka & Santa Fe Ry. at Amarillo, Tex., to succeed J. W. Walter.

The Chesapeake & Ohio Ry. announces the following appointments in the engineering department: **W. C. Pearce** has been appointed Division Engineer at Richmond, Va.; **F. D. Beale** has been appointed Acting Division Engineer at Clifton Forge, Va.; **J. W. Gleason** has been appointed Acting Division Engineer at Ashland, Ky., and **H. A. Bertram** has been appointed Acting Division Engineer at Peru, Ind.

The United States Office of Public Roads and Rural Engineering announces the following appointments of ten District Engineers, pursuant to the scheme of organization described in "Engineering News," Nov. 16, p. 961: **L. I. Hewes,** District Engineer, of District 1, including Washington, Oregon and Idaho, with headquarters probably at Portland, Ore.; **C. H. Sweetser,** M. Am. Soc. C. E., District Engineer of District 2, including California, Nevada, Arizona and New Mexico, with headquarters at Berkeley, Calif.; **J. A. Whittaker,** District Engineer of District 3, including Montana, Wyoming, Utah and Colorado, with headquarters at Denver, Colo.; **E. O. Hathaway,** District Engineer of District 4, including North Dakota, South Dakota, Minnesota and Wisconsin, with headquarters at St. Paul or Minneapolis, Minn.; **J. C. Wonders,** District Engineer of District 5, including Nebraska, Iowa, Kansas and Missouri, with headquarters at Kansas City, Mo., or Omaha, Neb.; **J. D. Fauntleroy,** M. Am. Soc. C. E., District Engineer of District 6, including Arkansas, Louisiana, Oklahoma and Texas, with headquarters at Dallas or Fort Worth, Tex.; **J. T. Voshell,** M. Am. Soc. C. E., District Engineer of District No. 7, including Michigan, Illinois, Indiana and Kentucky, with headquarters at South Chicago, Ill.; **J. T. Bullen,** M. Am. Soc. C. E., District Engineer of District 8, including Florida, Georgia, Alabama, Mississippi, South Carolina and Tennessee, with headquarters at Montgomery or Birmingham, Ala.; **Guy H. Miller,** District Engineer of District 9, including Connecticut, Delaware, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island and Vermont, with headquarters probably at Troy, N. Y.; **H. K. Bishop,** M. Am. Soc. C. E., District Engineer of District 10, including Pennsylvania, Ohio, West Virginia, Virginia, Maryland and North Carolina, with headquarters at Washington, D. C.

OBITUARY

Lawton T. Hemans, Chairman of the Michigan State Railroad Commission died Nov. 17, aged 52 years.

L. Marvin Willeroy, formerly of Richmond, Va., died at El Paso, Tex., Nov. 12. He practiced civil engineering in Mexico for many years, and at the time of his death was compiling data from his maps and records for the United States Army.

Col. William E. Craighill, formerly an officer of the Corps of Engineers, U. S. A., died Nov. 26, at his home in Washington, D. C. During the Boxer Rebellion in China he was transferred, at his own request, from the Corps of Engineers to the Infantry.

Leonard C. Rittenhouse, junior member of the firm of James H. Rittenhouse & Son, Civil and Mining Engineers, Scranton, Penn., died Nov. 10. He and his father were the engineers in charge of the interesting foundation work in the abandoned coal-mine workings under the Scranton Armory, described in "Engineering News," Oct. 12, 1916. He was a lineal descendant of Benjamin Rittenhouse, brother of David Rittenhouse, of Philadelphia, one of the foremost scientific men of the Revolutionary period. He was 32 years old and a graduate of Pennsylvania State College.

George H. Bailey, an engineering employee of the District of Columbia, died Nov. 25. He was 89 years old, having been born at Boston, Mass., in 1827. His earliest engineering experience was in the construction of Boston's first municipal water-supply, 1847 to 1852. From Boston he went to Jersey City, N. J., where he was engaged in the construction of the first water-works of that city. He is also said to have designed and supervised the construction of the first water-works of Newark, N. J. He went to Washington in 1878 as Computing Engineer of the District Engineering Department; subsequently he was Engineer of Bridges and Assistant Engineer in the Highway Department. Up to a few days before his death he was regularly at his office desk.

ENGINEERING SOCIETIES

PAVING BRICK INSTITUTE.
Dec. 5-6. Meeting in Cleveland at Statler. Asst. Secy., H. M. Macdonald, 830 Brotherhood of Loc. Engrs. Bldg., Cleveland, Ohio.

RAILWAY GARDENING ASSOCIATION.
Dec. 5-7. Annual meeting in New Orleans. Secy., Charles E. Lowe, Sewickley, Penn.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
Dec. 5-8. Annual meeting in New York City. Secy., Calvin W. Rice, 29 W. 39th St., New York.

NORTHWESTERN ROAD CONGRESS.
Dec. 7-8. In Chicago. Secy., J. L. Long, Moline, Ill.

PORTLAND CEMENT ASSOCIATION.
Dec. 11-13. Annual meeting in New York City. Assistant to General Manager, A. H. Ogle, Chicago, Ill.

OKLAHOMA SOCIETY OF ENGINEERS.
Dec. 27-28. Annual meeting in Tulsa. Secy., H. G. Hinckley, Oklahoma City.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS.
Dec. 27-29. Annual meeting at Chicago. Secy., D. K. Shedd, Ames, Iowa.

COMPRESSED GAS MANUFACTURERS' ASSOCIATION.
Jan. 15. Fourth annual meeting in New York City. Secy., O. S. King, 120 Broadway, New York.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
Jan. 17-18. Annual meeting at Society House, New York City. Secy., Charles Warren Hunt, New York.

AMERICAN ROAD BUILDERS' ASSOCIATION.
Feb. 5-9. Eighth National Good Roads Show, in Boston, Mass. Secy., E. L. Powers, 150 Nassau St., New York City.

TENTH CHICAGO CEMENT SHOW.
Feb. 7-15. In Chicago. Under management of Cement Products Exhibition Co., 210 South La Salle St., Chicago.

AMERICAN CONCRETE INSTITUTE.
Feb. 8-10. In Chicago at La Salle. Secy., H. D. Hynds, 30 Broad St., N. Y.

NATIONAL BUILDERS' SUPPLY ASSOCIATION.
Feb. 12-13. In Chicago at Sherman. Secy., L. F. Desmond, 1211 Chamber of Commerce, Chicago.

SOUTHWESTERN CONCRETE ASSOCIATION.
Feb. 19-24. Southwestern Concrete Show in Kansas City, Mo. Address Chas. A. Stevenson, 1413 W. 10th St., Kansas City.

The Third Northwestern Road Congress is announced to be held in Chicago, Dec. 7 and 8.

The Compressed Gas Manufacturers' Association will hold its fourth annual meeting at the association offices, 120 Broadway, New York City, on Monday, Jan. 15, at 2 p.m., the meeting being followed by a dinner at the Manhattan Club. The secretary is Otto S. King.

The Brooklyn Engineers' Club will hold its 20th anniversary dinner on Thursday, Dec. 7, at the Hotel Bossert, Brooklyn, N. Y. The club is departing from its usual practice for such an occasion by injecting some entertainment into the program. The secretary is Joseph Strachan.

The American Road Builders' Association announces the Eighth National Good Roads Show, to be held in Boston, Feb. 5 to 9, in the Mechanics' Building. This show is in conjunction with the 14th annual convention of the association, the program for which is now being prepared.

The Southwestern Water-Works Association will hold its 1917 convention at Topeka, Kan., June 11 to 14. This association draws its members from Missouri, Oklahoma, Arkansas, Texas, New Mexico and Louisiana, but all water-works men are cordially invited to attend the meeting, concerning which information may be obtained from E. L. Fulkerson, Waco, Tex.

The Alabama Technical Association, newly formed, held a banquet in Birmingham on Nov. 17, following which several prominent men of the state discussed methods for the development of the natural resources of Alabama. An important event at this meeting was the election of 12 directors, two from each of the six national societies represented, as follows: J. S. Sewell, O. G. Thurlow, M. J. Lide, Erskine Ramsey, J. R. Harris, Hugh Martin, W. S. Keller, J. H. Klinck, H. M. Gasman, H. S. Geisman, H. B. Battle, H. B. Wheelock. The secretary is Paul Wright, Birmingham, Ala. Martin J. Lide was elected temporary chairman of the board.

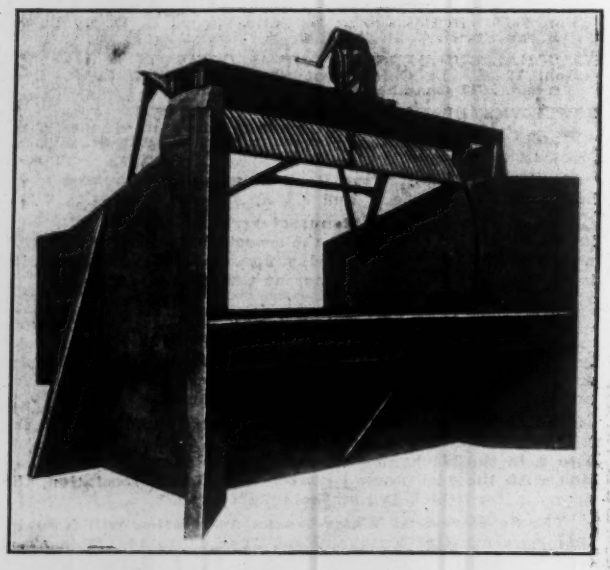
The American Bridge Engineering Club of New York City held a meeting on Nov. 15 at the St. Denis Hotel, at which an address was made on the structural shop and its relations to other departments by R. T. Lewis, Manager of the Elmira plant of the American Bridge Co. The club was organized about four years ago by the employees of the American Bridge Co., the object being primarily to increase the efficiency of the company's engineers, accountants and clerks

employed in the New York office. It was modeled after the Elmira Plant Engineering Club, organized in 1902. There are about 80 members and the average attendance at meetings is 55. The club holds eight meetings a year, at which a technical committee arranges to have a paper presented by some leading engineer of the club, or by an outside engineer having charge of work constructed by the bridge company. After the lectures there is discussion and then an entertainment is provided either by members of the club or by outside talent. The lecture is preceded by a dinner at a local hotel. An idea of the engineering program can be gained from the following subjects yet to be presented: Jan. 12, 1917, "Barges, Towers and Turntables"; Feb. 8, ladies' night; Mar. 14, "East New York Tunnel of the Long Island R.R."; Apr. 10, "Construction of Donora Plant"; May 11, "Omaha Bridge Over the Missouri River."

Appliances and Materials

New Radial Hydraulic Gate

Under the trade name "Calco" a new radial gate is being manufactured by the California Corrugated Culvert Co., in West Berkeley. This gate is unique in the fact that corrugated sheet metal is used to form the concave surface of the gate. The objection to radial gates is the leakage that occurs along the bottom and sides, which is generally overcome by fastening a strip of rubber belting along the sides and bottom. This gate is made tight along the bottom by means of a metal seat set into the concrete in which the lower edge of the gate is set when closed. At the sides of the gate the corrugations are flattened out so that sheet metal extends beyond the frame. This rides on an angle iron



RADIAL GATE WITH CORRUGATED SKIN

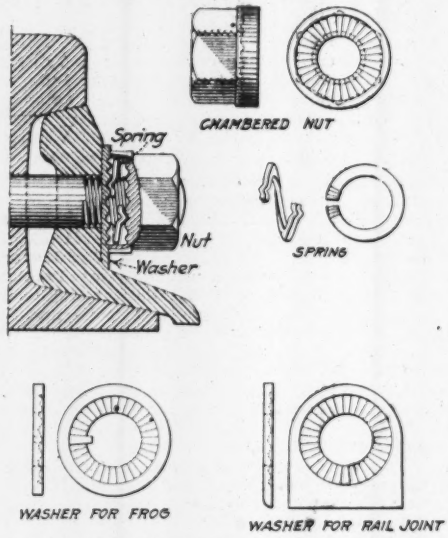
curved to the radius of the gate set into the concrete walls of the structure. The pressure of the water causes the sheet-metal extension to hug the angle iron closely and gives a tight joint. This company at present is endeavoring to equip these gates with an automatic control for maintaining fixed heads in canals. As yet, this device has not been perfected.

* * *

Tight-Grip Nut-Lock

A new spring nut-lock capable of exerting a strong pressure without damage to the thread of bolt or nut is being used in railway track fastenings, bridge work, machine bolts, etc., with very satisfactory results. This device is termed the O. K. nut-lock. It is manufactured by the O. K. Nut Lock Co., Turks Head Building, Providence, R. I. The accompanying drawing shows its application to rail joints and frog and switch work on the Delaware, Lackawanna & Western R.R. This road is using it also on bolts for fastening the rails to the ties, as noted in "Engineering News," of Oct. 19.

Against the splice bar or rail is placed a washer having a corrugated face. For the rail joint this has a horizontal edge which rests on the flange of the splice bar so that it cannot turn. For the frog work; rotation of the washer is prevented by a projection which engages a groove in the side of the bolt. The nut is of special shape, having a recessed chamber with a face corrugated like that of the washer. Between these



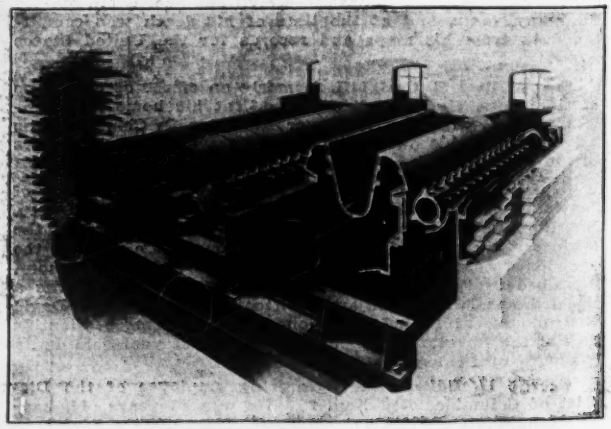
NUT-LOCK FOR RAILWAY TRACK WORK

two parts is fitted a spiral spring of high capacity, having its ends bent so as to engage with the corrugations. The washer is made in a variety of shapes to meet different requirements.

* * *

New Underfeed Stoker

A new design of underfeed stoker, with open-top horizontal retorts into which coal is fed by horizontal rams, has been developed by the Moloch Stoker Co., of Chicago. There are no grates used with this stoker. The coal is forced by plunger from hoppers into longitudinal V-shaped retorts. The coal, as it burns, passes over the top of the retorts and moves across the furnace bed into the inter-retort zones. Here the refuse is crushed by toothed rolls and is fed past aprons, dropping finally into the ashpit. Under each retort is an air box with preheating tuyere tubes going through the top of the retort walls to the fuel bed. Stoking units are independently supported at the front and at the bridge-wall. The coal plunger is operated by a piston in a double-acting steam cylinder. Automatic regulation of fuel and



TWO-RETORT MOLOCH STOKER FURNACE

air supply is secured by varying the speed of the forced-draft fan in accordance with the steam demand; this fan operates a timing device to close electric contacts in the coal-plunger valve-control solenoid circuit, or to work pilot valves to the same end.

For small boiler installations where there is no ash-removal equipment, a type of stoker has been made without the ash crusher and discharge apron. There are instead grate bars spanning the interval between retorts.